JANUARY, 1958
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food technology

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IN THIS ISSUE—

THE TECHNICAL ARTICLES IN BRIEF

Sensory testing

Effect of sample size, swallowing, rinsing

Quantity of sample, swallowing, and rinsing factors in flavor preference testing of tomato juice. L. A. Pettit.

With respect to the preference for tomato juice by college student panels, (1) rinsing the mouth with tap water between tastes has no effect on the preference expressed by the flavor panel; (2) swallowing the product produces more accurate preference results than not swallowing it; (3) flavor panel preference is altered by the quantity of sample consumed by the taster. When a larger quantity is consumed, truer results are obtained than when a smaller quantity is consumed. (See page 1)

Heat processing

Kinetics of inactivating bacteria

Kinetics of bacteriological inactivation by heat. S. E. Charm.

It is possible, using a kinetic approach, to derive the equation describing the logarithmic survival curve of bacteria. Therefore, it may be that the logarithmic survival curve is due to the kinetics of inactivation. The inactivation energy E_a varies with different species of bacteria but is essentially constant with temperature. The pH of the medium may affect the inactivation energy and in this way change the rate of inactivation. The pH is known to affect the inactivation energy of chemical reactions. The Frequency Factor S varies with temperature and slightly with medium. It changes greatly between different species. The increase in inactivation rate with increase in temperature is due to the increase in the number of collisions per unit time between surrounding water molecules and sensitive volumes as well as to the increase in numbers of water molecules possessing the energy of inactivation. (See page 4)

Methodology *Rancidity in fishery products*

2-Thiobarbituric acid method for the measurement of rancidity in fishery products. II. The quantitative determination of malonaldehyde. Russell O. Sinnhuber and T. C. Yu.

Oxidative rancidity in fat-containing foods leads to the formation of malonaldehyde or derivatives of this compound. The red reaction product formed by the reaction of malonaldehyde and 2-thiobarbituric acid (TBA) is an effective means of measuring the extent of autoxidation. TBA procedures previously described, though useful in studying the development of oxidative rancidity, are of empirical design. A quantitative, 2-thiobarbituric acid procedure for measuring malonaldehyde, using the stable compound 1,1,3,3-tetraethoxypropane as a standard, is proposed. Acid hydrolysis of 1,1,3,3-tetraethoxypropane yields malonaldehyde which reacts with 2-thiobarbituric acid, under the conditions described, to afford a quantitative method for determining malonaldehyde. The term, TBA number or milligrams of malonaldehyde per 1000 g. of material, is suggested. Reaction time, total recovery, and spectral characteristics of this reaction compound are presented. The method is sensitive to 10^{-8} moles of malonaldehyde in 100 ml. of solution. The autoxidation that occurs in frozen tuna scrap and the effect of the antioxidants, diphenyl-p-phenylenediamine (DPPD) and Tenox IV, in preventing oxidative rancidity was followed with this procedure. (See page 9)

Sensory testing

Effect of pre-informing subjects

Information bias in flavor preference testing. L. A. Pettit.

If the information conveyed to tasters has meaning within terms of experience, it may influence their preference. This suggests that tasters may taste what they expect to taste. From these flavor tests it is indicated that information conveyed to, or possessed by, tasters has the potential of altering preference findings of the flavor panel. (See page 12)

New products *Wheat-and-rice bread*

A new type of bread: Wheat-and-rice bread. Alejandro Mosqueda-Suárez.

A wheat-and-rice bread is offered as a substitute for common wheat bread. Its organoleptic qualities are equal to other breads. The nutritional requiremnts for a good bread are met. Use of 30% rice replacing wheat flour was chosen as a result of considering Venezuelan agro-economical and nutritional conditions. Protein efficiency of the wheat-and-rice bread was greater by 9.1% and the growth of rats by 7.7% as compared with wheat bread even though the latter contains 12.73% protein whereas the wheat-and-rice bread contains only 11.78% protein. The new wheat-and-rice bread can be made in any bakery and only requires 25% more yeast than is usual. But it must ferment 15 minutes longer under the action of yeast, when the straight dough method is applied. The wheat-and-rice bread could have a favorable influence on Venezuelan economy, since rice is a product that this nation produces in considerable volume. (See page 15)

January Cover. Flavor, the *sine qua non* of food, is an elusive quality that the flavor houses of America and of nations overseas have researched for decades. Strength, stability, naturalness, increased aroma, economy — these are some of the objectives that the flavor chemist seeks by means of ingenious techniques and such elaborate distillation apparatus as is shown (courtesy of Fritzsche Brothers, Inc.) on the January cover.

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FT food technology

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Packaging *Prepackaged meat*

Factors affecting quality of prepackaged meat. II. Color studies. D. Effects of nitrogen and carbon dioxide under different pressures upon color of products. John A. Rikert, C. Olin Ball, and Elizabeth F. Stier.

Flushing storage atmospheres with carbon dioxide or nitrogen before vacuum storage had, in general, a beneficial effect on color of both fresh and cured meats as compared with samples stored in vacuum without previous flushing. When fresh beef and cured ham were stored under a pressure of about one atmosphere, and the partial pressure of carbon dioxide was varied from 0.2 cm. to 72 cm., rate of discoloration of fresh beef varied directly with the partial pressure of carbon dioxide and that of ham inversely with the partial pressures of carbon dioxide. Varying the partial pressures of nitrogen from 59.4 cm. to 74.5 cm., while maintaining a total pressure of one atmosphere, gave similar results with beef, and questionable results with cured ham. High carbon dioxide partial pressures maintained the color of cured meat better than high nitrogen pressures. (See page 17)

Storage practice *Military rations*

Moisture condensation and cold stored military rations. J. G. Woodroof and E. K. Heaton.

Moisture condensation or "sweating" may occur on military rations at any time they are subjected to a warmer temperature, to removal from storage into a humid, warmer atmosphere or to sudden admission of warm, humid air to the holding spaces. However, the usual ill effects associated with moisture condensation have not been found to be of major importance in refrigerated storage of assembled combat rations. The reasons are the selection and use of good packaging materials. Under prevailing practices, condensation is related to one or more of the following: nature of the items packaged, the type of package (tin cans attracted most moisture), storage conditions before assembling, and conditions for assembling, storing and warming-up. Moisture condensation was found to be associated with the density, heat capacity, and heat conductivity of the product. It was worst on such products as canned apricots, corn, meat balls and spaghetti and least on canned soluble coffee, dry cream, and cookies. In general, products with the highest water content, or with the heaviest syrups, had the most condensation. (See page 24)

Sensory testing
Effect of test site and other factors

Variations in preference ratings for foods served at meals. David R. Peryam and Norman J. Gutman.

This exploratory study of factors influencing soldiers' stated preferences for a constant food as served at regular meals in the dining hall was designed to investigate 4 possible sources of variation: (a) day of the week and (b) meal at which food was served, (c) mess hall used as test site, and (d) number of foods to be rated. Information was also obtained on changes from week to week. The test food was orange juice prepared from the dehydrate. Preference was measured by the hedonic scale method. Military teams conducted tests over a period of 3 weeks at 27 different meals in 9 different messes at Fort Lee, Virginia. Each test involved a sample of 25-30 respondents. All 3 daily meals, 3 different days of the week, and 3 questionnaire forms were included. The over-all range of mean ratings by test session was 2.50 scale points. Analysis of variance showed that the effects of day of the week and number of foods were not significant; however, effects of both mess-hall and meal were significant at the 1% level. Changes in rating from week to week were negligible. Implications of the findings for acceptance pretesting of military rations are discussed. (See page 30)

Antioxidant properties *Malt, malt sprouts*

Antioxidant in malt and malt sprouts. Dwight L. Baker and Nison N. Hellman.

Flours prepared from malt and malt sprouts, when added to fats or oils, inhibited the accumulation of peroxides upon aeration or oxygenation. Methanol extracts of malt sprouts showed enhanced antioxidant activity. Preliminary trials suggest usefulness of malt flour as a natural wholesome food ingredient to contribute antioxidant stabilizing the flavor of food products prepared with oil or fat. (See page 33)

Freezing technology *Red sour pitted cherries*

Time-temperature tolerance of frozen foods. XI. Retail packs of frozen red sour pitted cherries. D. G. Guadagni, C. C. Nimmo, and E. F. Jansen.

Nine lots of commercially packed frozen red sour pitted cherries were evaluated over 3 seasons. A small highly trained panel found definite texture and flavor differences in all lots after 3 to 4 weeks at 20° F. Color differences in baked pie did not change appreciably until cherries had been held 6 to 8 weeks. Most readily observable change in thawed unbaked cherries stored at 20° F. was browning of fruit exposed to headspace atmosphere. Hermetically sealed tins were superior to composite cartons in preventing enzymatic discoloration at elevated temperatures. Number of brown cherries and degree of browning as measured by the Hunter Color Difference Meter provided a means of estimating temperature history. Color distribution between cherries and surrounding sirup was also useful in determining time-temperature exposure. Soluble solids distribution was found especially useful as a thawing indicator. Most readily detectable change in pie-baked cherries was an increase in firmness with storage time. A linear relation was found between organoleptic assessment of firmness changes and tenderometer measurements. Storage under fluctuating temperatures and simulated distribution patterns indicated that changes which occurred under these variable temperature conditions were similar to those which occurred at an equivalent steady temperature. (See page 36)

Freezing technology *Turkey dinners, pies*

Time-temperature tolerance of frozen foods. XII. Turkey dinners and turkey pies. Helen L. Hanson and Lorraine R. Fletcher.

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Turkey dinners and pies, both laboratory and commercial preparations, were evaluated for flavor and other changes after storage in the range of −30° to 20° F. Stale and rancid flavors developed in from 1½ to 3 months in samples held at 20° F.; significant loss of ascorbic acid in peas used in turkey dinners occurred in 3 months at 20° F. Mild stale flavors and occasional rancidity developed in these products after 6 to 12 months at 10° F. and below. Thus, these products are 3 to 6 times as stable at 10° as at 20° F. Under the conditions used, adding an antioxidant did not improve flavor stability sufficiently to warrant its use in dinners stored one year at 0° F. or 6 months at 10° F. Temperatures fluctuating from 0° to 20° F. and from −10° to 10° F. did not cause flavor changes differing significantly from those held at the mean temperatures of 10° F. and 0° F. Peroxide values generally increased with lengthening storage time and higher temperature, but did not show sufficient correlation with rancid flavor development to serve predictive purposes. Samples held for a year at 10° F. or lower showed flavor changes only part of the time. For **optimum** retention of the desirable qualities of turkey dinners and pies, exposure to 20° F. should be avoided. Storage at 10° F. or lower should be limited to 6 months or less. (See page 40)

Measurement, color *Sockeye salmon*

Predicting the color of canned sockeye salmon from the color of the raw flesh. P. J. Schmidt and D. R. Idler.

Color grade of salmon must be predicted prior to canning. This study has shown that the Gardner Color-Difference Meter is a suitable instrument for the color measurement of raw and canned sockeye salmon. It was determined that a reading alone is a suitable measure of the color of canned salmon and can be best predicted from the a/b ratio of the raw fish. Three grades with specifications in terms of color measurements of both raw and canned fish have been proposed. It was found that in general the canned salmon with the higher oil content had a slightly better color. Small increases in the time and temperature of processing resulted in slightly greater color losses. Color losses during processing were not significantly affected by the **post-mortem** storage of the fish in ice or refrigerated sea water prior to canning. (See page 44)

Measurement, color *Fruits, vegetables*

A method of evaluating modifications in sample presentation to the Hunter Color-Difference Meter. A. H. Bockian and R. Wm. Hirzel.

Due to color differences between fruit pieces and sirup, difficulty in obtaining uniform samples, and slowness of the existing method, the Hunter meter and sample presentation method have been modified to eliminate certain objections to previous methods. The modified instrument allows the sample dish to rotate in a plane parallel to the top face of the meter and permits the standard tiles to be used in the same position as the sample dish. Certain colored chemicals were used to determine the sensitivity of the modified meter to small differences in color. Compared to the original instrument the modified meter is equally sensitive and more precise and reliable in measuring color differences. (See page 49)

Sensory testing
Bread from irradiated flour and wheat

The level of irradiation at which taste change is noted in bread made from irradiated flour and irradiated wheat as deduced from taste panel results. R. Nicholas, D. P. Meiske, M. F. Jones, D. E. Wiant, I. J. Pflug, and E. Jones.

Bread made from irradiated flour and flour milled from irradiated wheat were studied to determine the level of irradiation that would produce distinguishable taste and/or odor changes. Results were analyzed by probit analysis to determine the level of irradiation at which half the judgments (above chance) of the taste panel as to the odd sample in a triangle test were correct. The level in question was found to be at about 50,000 rep in each case. (See page 52)

Sensory testing *Test location and sound*

The influence of test location and accompanying sound in flavor preference testing of tomato juice. L. A. Pettit.

These tests demonstrated that, with respect to tomato juice as evaluated by a college student panel, the 3 locations in which flavor tests were conducted did not alter the preference findings of the taste panel, and that generalized sound, typical of a large restaurant, as contrasted to quiet, did not affect the preference results. Analyses indicate that all tasters did not agree in their individual preferences, but panel preference did not change from location to location nor with sound or quiet. Flavor preference for tomato juice by this panel could be equally well ascertained in any of the 3 locations examined and neither restaurant-like sound nor maximum quiet was an influence. (See page 55)

Processing technology *Apples for applesauce*

Time and recovery factors in processing of applesauce. Anthony Lopez, Charles B. Wood, and Joseph M. Johnson.

Factors which affect time and recovery of various fractions in peeling and trimming operations and their interrelationships are considered. Fractions were (1) peels and core, (2) trim waste, (3) prepared apples. No significant difference was found among the 4 varieties (York Imperial, Golden Delicious, Stayman, Grimes Golden) for yield of prepared apples and of peel and core waste. Varietal and grade differences were found for U. S. No. 2 apples in per cent trim waste. Trimming time increased as size decreased and as total trim increased. York Imperial required longer to trim than the 3 other varieties. Variations in peels and cores and in total trim waste were the greatest cause for variations in yield. Because of the relationship of size of apples with both peel and core waste and total trim waste, size was more important than was grade. Variations in grade and in size have about equal effect on trimming time. One per cent increase in defect trim resulted in approximately 2.5 minutes increase in trimming time for 100 lbs. of apples of any size. Trim resulting from removal of defects had nearly double the effect on trimming time than trim resulting from peel removal. The estimating equations developed from methods used in Experiment II of this study may be used in applesauce processing plants for determining differential costs of peeling and trimming apples of different size and quality. (See page 57)

Pressure Dispensed Food Packaging*

P. B. Gottschall and E. D. Giggard

Metal Division Research and Development, Continental Can Company, Inc.

UNTIL RECENTLY, pressure dispensing of food products was limited to those foods customarily used as a foam. The permissible gas propellants and the valves that could be used commercially with these propellants would only be adapted to the production of a highly aerated product. Thus, the market for pressure dispensed food packages was limited to whipped cream and a few whipped toppings.

These products were first introduced in 1947 and by 1949 production reached an estimated 30 million units, or about two times that of nonfood aerosols. Despite this early and favorable response, since that time pressurized foods have grown at a slower rate. They reached an estimated 70 million units in 1956, but nonfood aerosols in the same period reached a production in excess of 300 million units. The variety of nonfood products adapted to pressure dispensing, moreover, are numerous and ever increasing, but foods have been limited to the one-type product. It is interesting, however, that to date no single class of nonfoods—including the large volume hair lacquers and shaving creams—has exceeded this present food leader in production.

P. B. Gottschall (left) and E. D. Giggard (right), authors of this article and leaders in the project to expand the applications of pressure dispensed food packaging.

The tremendous potential of other pressurized food products, spurred the desire of food manufacturers to develop pressure containers for such products as catsup, salad dressing, barbecue sauce, mustard, syrups, and oils. However, their desire was easily discouraged by the dispensing characteristics obtained with available containers and the packing methods that could be employed. In addition to being objectionably aerated, product appearance produced by this aeration destroyed the identity of the product—and would be intolerable to manufacturer and consumer alike. Using condensible or liquefied propellants similar to those used for nonfood aerosols, or designing a container which did not permit contact of the propellant with the food were suggested as solutions. In the former case, approval from governmental regulatory authorities would be required; in the latter, considerable development work would be necessary. Both approaches would involve a considerable amount of time and were therefore not pursued.

A New Approach

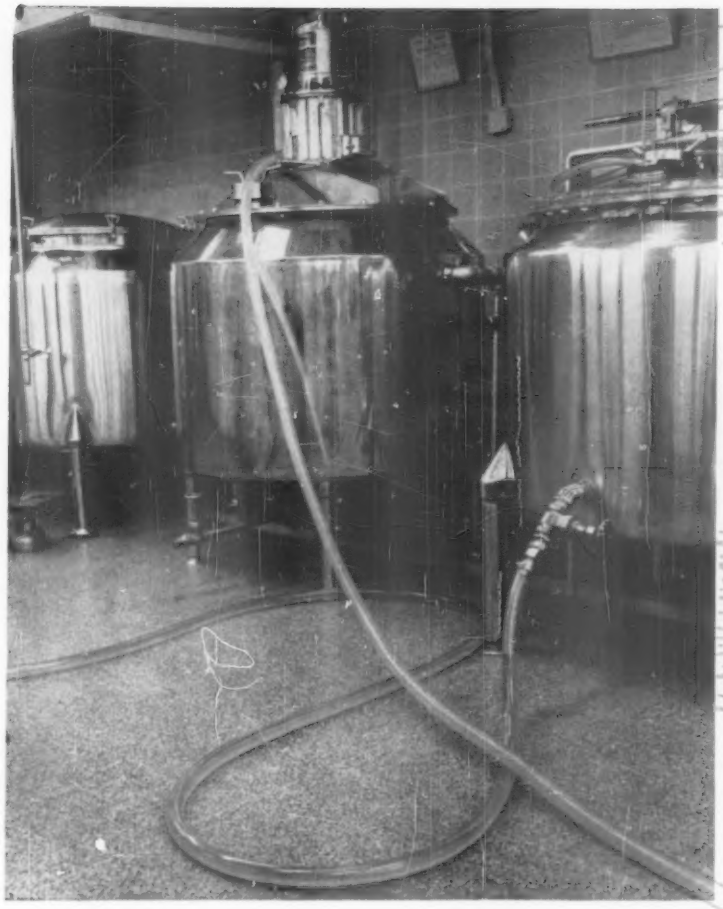
Late in 1956, Continental's Metal Research and Development Laboratory achieved encouraging results by following a new avenue of approach. A method of charging compressed gases through most of the available nonfoam and foam type valves, at allowable pressures, was devised. This accomplishment enabled us to make a complete study of the effects of variable compressed gas mixtures and pressures with various types and sizes of valve actuator buttons on the spray characteristics of a particular food product.

It was found early in our experimental work that any of the desired spray characteristics such as foam, heavy stream, high velocity stream or spray could be obtained with water and/or salad oil. In several instances, this required the combination of one manufacturer's valve with another's valve actuator button. This was enlightening in that it indicated that little trouble should be encountered in obtaining desired dispensing characteristics with low viscosity, water-based or oil-based products.

As this work progressed on specific products obtained on the open market or submitted by interested food manufacturers, it was learned that many factors were involved in obtaining desired dispensing characteristics with maximum product delivery. The most important were: product viscosity and discrete particle size; gas propellant employed; gas charging and equilibrium pressures; product fill; shaking time during gassing; and valve and actuator employed.

The influence of several of these factors on product dispensing characteristics and on internal volume-pressure changes occurring during the dispensing period are illustrated in Figures 1 and 2. The relationship of product fill to rate of pressure drop during dispensing is clearly evident. A direct re-

* From an In-plant Seminar, November 1, 1957.



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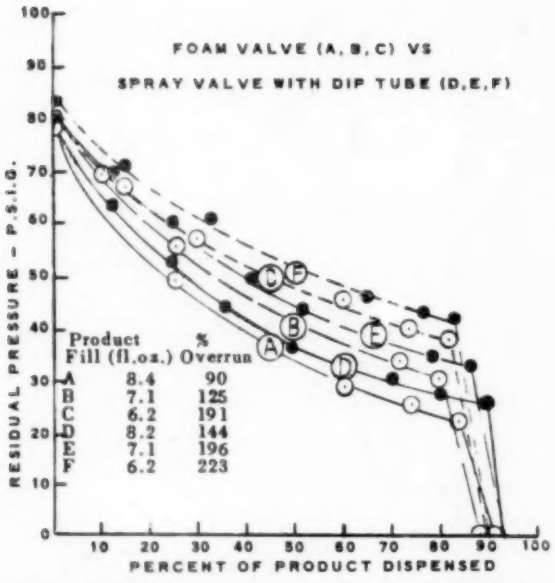
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RESIDUAL PRESSURE - P.S.I.G.
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B 7.1 125
C 6.2 191
D 8.2 144
E 7.1 196
F 6.2 223

Figure 1. Relationship of product fill to rate of pressure drop during dispensing of an N_2 charged product. (Maple syrup—Sp. Gr. 1.33)

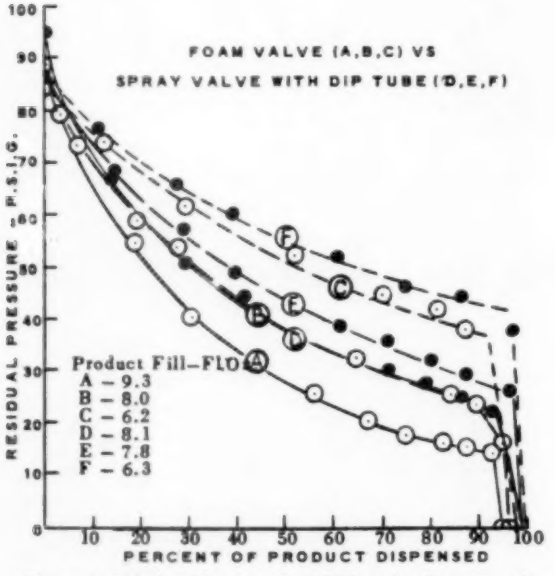

Figure 2. Relationship of product fill to rate of pressure drop during dispensing of an N_2O–CO_2 (85:15%) charged product. (Mayonnaise-type salad dressing—Sp. Gr. 1.03)

lationship is expected in that a given volume of product dispensed from a 9-fluid-ounce fill, for example, represents a greater percentage increase in headspace volume than a similar amount dispensed from a container filled with 7 fluid-ounces of product. Rate and total amount of internal pressure drop are also affected, but to a lesser degree, by the type of valve and gas propellant employed. It has been our experience that when packed under similar conditions, the spray type valve with dip tube results in higher product delivery values for most products than does the whipped cream-type foam valve.

Overrun, a measure of product expansion during dispensing, is inversely related to product fill and directly related to residual can pressure. Solubility of propellant in the product is also an important factor when considering overrun in foam products charged with compressed gases. The degree of overrun attained in products dispensed as a foam can be regulated in several ways. Maximum product overrun can be atained by using the propellant having the greatest solubility in the product, at the highest allowable pressure and in combination with the lowest practical product fill.

Product characteristics dictate dispensing forms

The viscosity or fluidity of the food product, to a considerable degree, determines whether it can be pressure-dispensed satisfactorily under allowable pressures, the dispensing forms that can be obtained, and the amount of product delivery. Generally, low viscosity products such as salt solutions, beverage syrups and oils can be dispensed easily in any desired form with greater than 95% product exhaustion. An aerosol or wet spray is obtained more easily than a foam with low viscosity products. In many instances an added stabilizer is required to obtain a foam. More viscous products such as barbecue sauces, catsup, mustard and sugar syrups (cane, maple, etc.) are more difficult to dispense as a spray. An aerated or nonaerated stream or ribbon is produced more easily with these products. Obtaining a spray generally requires reformulation of the product and/or a specially designed actuator orifice. Highly viscous products such as fudge toppings and icings, in their ordinary form, cannot be dispensed satisfactorily at existing allowable pressures. In addition to being too thick to be forced through the valve orifices, a considerable amount of the product adheres to the container walls and would result in low product exhaustion.

Products containing discrete particles such as ground spices, seeds and undissolved solids can be expected to present dispensing difficulties due to valve clogging. The particle size must be considerably smaller than that of the smallest valve orifice because even particles a little smaller than the orifice size will build up in the valve channels and cause a jam in front of the orifice. In our initial work with .040-inch multiple orifice valves, it was found that most products had to be passed through a .023-inch screen before packing to prevent subsequent valve clogging. In a few cases, the screen size had to be reduced below .023-inch. The relative quantity of particles involved has a lot to do with the allowable size. Presence of fewer particles reduces the tendency for jamming and allows a particle size closer to that of the smallest valve orifice size.

The specific gas propellant or propellant mixture employed with a pressurized food product controls

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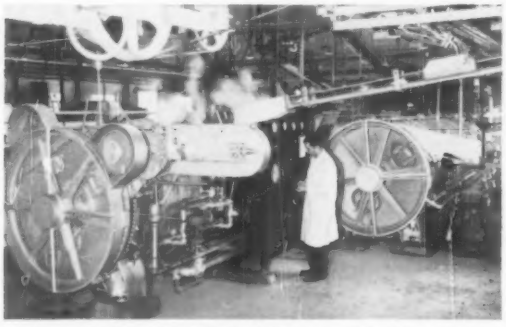

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to a great degree, the form the dispensed product obtains. Permissible gases currently used—either singularly or in combination—are nitrous oxide, carbon dioxide and nitrogen. There are other others such as argon that can and may be used for special purposes but their cost is generally prohibitive. The form of the dispensed product is dependent upon the solubility of the gas in the product which is dependent upon gas identity and proportional to pressure involved. At a given pressure, the greater the gas solubility the greater will be the aeration or foaming of the product emitted from an unrestricted valve. In our work, it was found that wet sprays or aerosol mists were more easily obtained from mechanical break-up actuators when gases of greater solubility were used. It seems logical that a product is more easily disintegrated when in an aerated rather than continuous form.

In general, the descending order of solubility of the commonly used gases in food products is carbon dioxide, nitrous oxide, nitrogen and argon, although nitrous oxide is slightly more soluble than carbon dioxide in edible oils.[b] Therefore, if a nonaerated stream is desired for a liquid food product, it is better to approach the problem using nitrogen as the propellant, or argon if costs permit. If a foam or spray is required, the solution involves the use of nitrous oxide, carbon dioxide or a suitable mixture of these gases. The final selection will probably be dependent upon organoleptic qualities imparted to the product by the specific gases and the economic advantage of one gas over the other.

Charging pressure and equilibrium pressure

In pressure-dispensed food work, 2 gas pressures must be considered: the *charging pressure*, or pressure at which the gas is introduced into the container; and the *equilibrium pressure*, the pressure in the can at a given temperature after equilibrium between product and gas has been reached. According to ICC regulations, the latter cannot exceed 100 p.s.i.g. at 70° F. The 2 pressures are the same only if complete saturation of gas in the product takes place during charging and the temperature of the product is the same at equilibrium as when charged. In commercial practice, fairly complete saturation of soluble gases is obtained by vigorously shaking the cans during charging for specified periods of time (10 to 30 seconds depending upon the solubility relationships of product to gas, product viscosity, etc.). Most observed differences encountered between these 2 pressures may be attributed to temperature differences. If a product is charged at a temperature above 70° F., the equilibrium pressure at 70° F. will be lower than the charging pressure due to increased gas in solution and reduced free headspace gas pressure at the lower temperature. The reverse is true for products charged with gas at temperatures below 70° F. Examples of the temperature-pressure relationships in products charged with nitrogen and a nitrous oxide-carbon dioxide mixture (85:15% ratio) are shown in Figure 3. These data show that an increase in product temperature of 10° F. results in a pressure increase of 3 p.s.i.g. for nitrogen-charged products and 7.5 p.s.i.g.

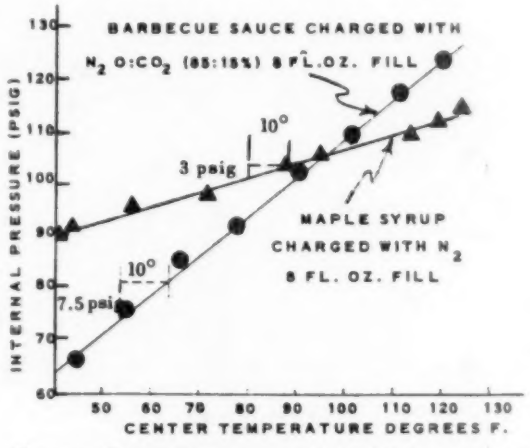

Figure 3. Temperature-pressure relationship in pressure dispensed foods.

for products charged with a nitrous oxide-carbon dioxide gas mixture. The greater rate of pressure increase for the latter is caused by decreased solubility of the gas at higher temperatures. By comparison, the nitrogen gas is practically insoluble at all temperatures.

Product fill in pressure containers generally ranges from 60% to 85% of the total container capacity. This is approximately 7 to 10 fluid ounces for 12-ounce containers and 9 to 13 fluid ounces for 16-ounce containers. The actual fill employed for a specific product is usually a compromise dependent upon the dispensing characteristics required and the amount of residual product that can be tolerated. Variance in product fill at similar pressures has less effect upon the dispensing properties of nonaerated products than on aerated products. Where aeration is not desirable, and a propellant having minimum solubility is used, the fill can be in the high part of the range. On the other hand, products requiring a high degree of foaming and overrun are charged with soluble gases and filled at the lower area of the range.

Velocity, viscosity, and valves

The last important consideration in obtaining desired dispensing characteristics with food products is the valve and valve actuator design. The solution generally lies with the latter because design of the valve actuator (containing the last orifice the product passes through) plays a most important part in the resultant dispensing form of the product. It can be

[b] Based on work conducted by Air Reduction Company with edible oils, water, and sugar solutions.

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readily demonstrated with several valves on the market today that a change from spray to wet steam to aerated ribbon can be made with various products by changing to actuator buttons of varying designs. In our work, we found that a crude modification in the size or shape of the actuator orifice made a tremendous difference in dispensing characteristics of some products. Selection of the proper valve is not difficult as several of the valves available commercially will generally do a satisfactory job. The main consideration is the minimum orifice size in the valve selected. This should be as large as possible for most viscous food products to allow high velocity, free flow of product into the valve actuator.

A Trend Is in Evidence

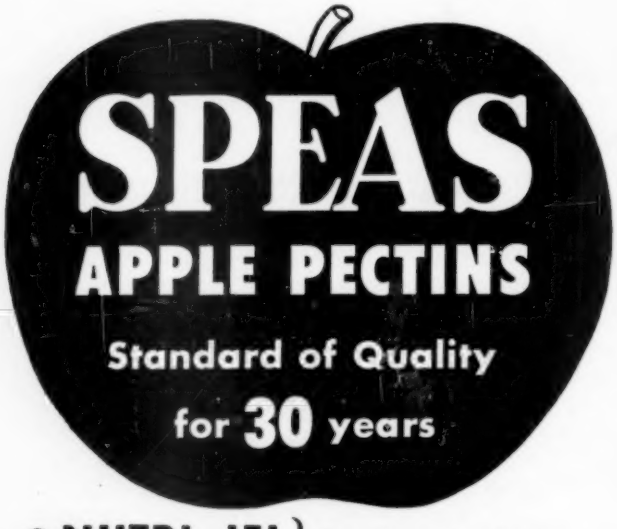
Continuation of the present enthusiastic interest in pressure dispensed foods could result in food aerosols exceeding the volume of nonfoods aerosols within a few years. No doubt various technological problems will be encountered with each new product attempted as there were with every nonfood product persently on the market. However, the cooperative efforts of container manufacturers, valve and propellant suppliers, custom loaders, and food processors will insure success with a good line of products. Already, barbecue sauce and chocolate syrup are being marketed in pressure containers. Salad dressings, meat sauces, mustard and catsup are prospects for the near future.

CHECK LIST OF FOOD RESEARCH TITLES FOR JANUARY-FEBRUARY

Nineteen articles covering a considerable range of research will appear in *Food Research* for January-February. Two articles on the browning of sugar solutions open the book, followed by a method for determining pectic substances.

Studies on poultry problems include two articles on the bacteriology of frozen stuffed turkey, the volatile carbonyl compounds of cooked chicken, and the effect of xanthophyll on the stability and palatability of turkey meat.

Enzyme action and off-flavor in frozen peas is the subject of an article in the category of research on vegetables and the ascorbic acid content of baked potatoes is another. The effect of gamma radiation on bacterial spores is treated and there are a number of articles relating to heat processing, including one on the factors affecting the thermal resistance values obtained by the thermoresistometer method.



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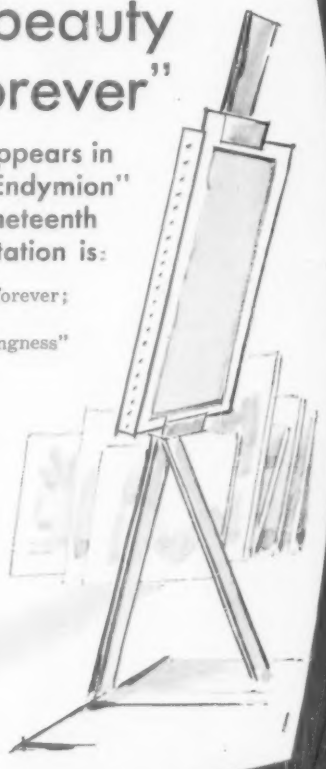

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Of Professional Interest

Progress Report—Eighteenth Annual Meeting of the Institute of Food Technologists

SHAPING UP FAST are events and programs for the 18th annual IFT meeting to be held May 25-29, in Chicago, according to the committee chairmen, now getting into high gear as the meeting date looms up on the 1958 horizon.

Registrations will be easier and faster, and rooms will be plentiful, reported Warren Schack, of Swift & Co., who heads the registration committee. Major portion of the expected 2,500 registrants will come from the Chicago area. For out-of-town technologists, 1,000 rooms will be held by the Palmer House.

Pre-registration cards will probably be mailed between mid-February and March 1st. The room-reservation card, however, must be mailed directly to the hotel.

Spearheading the programming of the 18th Annual Meeting of IFT are Drs. Robinson (Swift & Co.), Beach (Libby, McNeill & Libby) and Jackson (American Can Co.).

During the meeting, registration desks will be set up in the Grand Ballroom foyer on the Palmer House-mezzanine floor. Three lines will be set up for registration, pre-registration and events tickets, for speed-up purposes. This separate ticket line will provide more room and eliminate the confusion sometimes experienced.

CHUCK WAGON DINNER TO BE A FEATURE

George Brissey, Swift & Co., stated that his general entertainment committee has made arrangements to start off the '58 annual meeting with the traditional social period from 8-11 P.M., Sunday, May 25th, in the Grand Ballroom of the Palmer House.

Two surprise highlights on the entertainment schedule will include:

1. A chuck-wagon dinner at 9 P.M. on May 26th. It'll be held at the International Amphitheatre in the Stock Yards, featuring entertainment by Captain Stubby and his Pirates, Red Blanchard and others from the staff of radio station WLS.

2. Special entertainment involving European high nobility at the Award Banquet on Tuesday, May 27th.

FOR THE LADIES

Barbara Evers, of the National Dairy Council, says her courtesy committee will offer complete information service—on shopping, transportation, entertainment, theatres, restaurants, points of interest, etc.—about the city of Chicago. Committee will also operate a "Lost and Found" department, transmit messages to attendants at sessions, provide other general courtesies, but won't baby-sit.

Margaret Ives, of American Can Co., reports that the ladies entertainment committee has scheduled an informal tea for wives, husbands, girl friends and boy friends, on Sunday, May 25th, from 4-6 P.M., at the Palmer House. Arranged is a tour of *Marshall Field & Co.*, with a luncheon set up for 11:30 A.M. on the next day—the 26th. Tuesday's program includes luncheon at the famous *Milk Pail* restaurant and a tour of the *Haeger Pottery Works*, in Dundee, Ill. Wednesday's plans have not been formalized, but the ladies can look forward to something especially entertaining.

FIELD TRIPS

Arrangements have been completed by Louis G. Buettner, of International Minerals & Chemical Corp., and his field trip committee to visit:

1. Research facilities of Continental Can Co., Chicago.

2. Production facilities of Corn Product Sales Co., Argo, Ill.

3. Sheet & tin mill of U.S. Steel Corp., Gary, Ill.

4. Meat packing operations of Armour and Company, Union Stock Yards.

5. Argonne National Laboratory, Lemont, Ill.

6. University of Chicago, Chicago. This trip will cover visits to the Institute of Nuclear Physics, Metallurgical Lab, Low Temperature Lab, Food Research Lab, American Meat Institute Foundation, Argonne Cancer Research Hospital and Oriental Institute.

Committee members Louis Buettner, Warren Schack, Colonel Lawrence and George Brissey discuss a scheduling problem at a recent Committee meeting held at the Midland Hotel.

TECHNICAL PROGRAM PROGRESS

And the technical sessions' chairmen have not been twiddling their thumbs. Space permits only a sampling but here are a few progress notes:

Radiation Preservation of Foods. H. W. Schultz, Oregon State College, reports that a program consisting of at least 14 papers will emphasize three principal group subjects: (1) methods of applying radiations to foods; (2) microbiological aspects, involving probable minimum dosages for complete destruction of those organisms, like *Clostridium botulinum*, that represent a health hazard; and (3) attempted evaluation of status of radiation sterilization of foods from consumer-acceptance standpoint.

First group of subjects may lead to papers dealing with the radiation chemistry of normal food components that may result in undesirable odors and flavors. Co-chairman of the technical committee sessions, John Jackson, American Can Co., indicates that a full-day session may well be devoted to irradiation of foods.

Meat, Fish & Poultry. C. K. Wiesman, of Armour and Company says he cannot determine as yet what the general emphasis will be. However, titles received up until now indicate considerable interest on the part of universities.

Citrus Products. Program for this session according to chairman H. W. Trumm, Libby, McNeill & Libby, is shaping up nicely. There'll be papers from California, Florida and Texas, covering basic and applied research as well as certain technical production aspects of several new citrus items.

Packaging: Consideration is being given to aerosol packaging of foods, states chairman L. J. Hayhurst, Kraft Foods Co. There are hopes of getting can and valve manufacturers as well as a packer into a panel session.

Instrumentation. Chairman J. H. Bock, Continental Can Co., has six tentative papers dealing with: (1) Use of X-Ray in food industry, (2) single-panel applications of process control, (3) method for measuring rheological properties of shell eggs, (4) evaluation of light transmittance technique for maturity measurement of Italian prunes, (5) instrument using light transmittance for nondestructive measurement of fruit maturity, and (6) colorimetry of strawberry preserves.

Research on Foods for Military Use. Eight papers are reportedly projected in a tentative way by chairman R. G. Tischer, Qm. Food & Container Institute for the Armed Forces.

They deal with (1) Quick serve meals used by the army, (2) projection of new research areas in the Qm. Food and Container Institute, (3) combination food preserving techniques, (4) acquired preference for novel foods, (5) procurement and distribution of military foods, (6) Great Britain's point of view on military feeding, (7) components of simple food logistics, and (8) space feeding (for rockets, jets, space ships, etc.).

SYMPOSIA

J. M. Jackson, American Can Co., will chairman a symposium on operation research. Three speakers, as now planned, will discuss purchasing, production planning and inventory control; case histories on applications of operation research to crop harvesting and planning developed by several food packers; and several case histories dealing with application of operation research to various food-plant operations.

In a food fats symposium, E. E. Rice, Swift & Co., expects to have five papers. They'll cover types and quantities of fats available for food use, processes involved in converting raw fats into usable commercial products, animal tests relating to fat in the diet, clinical reports on influence of fat in diet, and outline the importance of fats in diet.

—John V. Ziemba, *Publicity Chairman*

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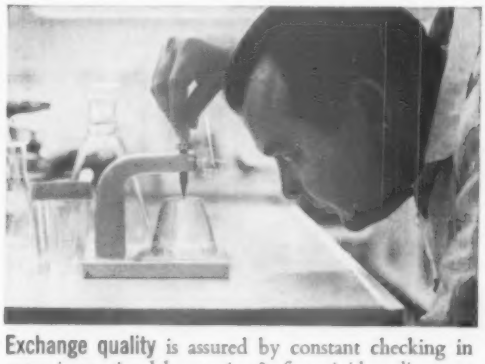

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Membership Drive Regional Chairmen Appointed

A CONCERTED EFFORT is now underway to increase membership in the IFT and to bring into the Institute those well-qualified food technologists who can contribute to as well as gain much from the organization.

SIX THOUSAND MEMBERS OR MORE IN '58

A goal of better than 6,000 members has been set for 1958, and to reach this goal it was decided to establish committees in each section to handle national membership activities.

Carl H. Koonz, chairman of the National Membership Committee, reports that chairmen for each of these committees have been appointed, and in turn they have established local committees to help secure new members.

These men, Dr. Koonz said, can be contacted by those who want to join the IFT or by members who might have friends or associates whom they feel should be members of the Institute.

This is an excellent time, Dr. Koonz pointed out, for members to think seriously about raising the membership over the 6,000 mark. It may not be an easy task, he said, and it will take a great deal of work, but if everyone makes an effort, the results will be more than gratifying.

spice RESEARCH NEWS

New Methods for Analyzing Spices Aid in Determining Flavor Strength

New techniques and apparatus for testing the volatile oil content of spices have been developed in a recent research project.*

Using a newly modified Clevenger trap plus new distillation procedures, researchers have been able to shorten the normal analysis time by several hours and also obtain greater accuracy.

The Clevenger trap has been changed to include a more precisely calibrated tubing and designed in two parts instead of one, so that it is possible to test oils both heavier and lighter than water with only a slight adjustment.

A reduction in distillation time is made through use of a magnetic stirrer. This allows a higher heating mantle temperature without danger of scorching, eliminates the chance of superheating and makes anti-foaming agents unnecessary.

Use of the new methods and equipment for testing volatile oil content makes the determination of flavor strength in Natural Spices a faster, easier and more accurate procedure.

* Published in the Journal of the Association of Official Agricultural Chemists.

* * * *

Reprints of the report on this study are available from the Information Bureau, American Spice Trade Association, 350 Fifth Avenue, New York 1, New York.

American Spice Trade Association

CONTACT THESE CHAIRMEN FOR INFORMATION

The following is a list of section membership chairmen who can be contacted for further information:

Oregon section, Dr. Arthur W. Anderson, Department of Bacteriology, Oregon State College, Corvallis, Ore.; **Northeast section,** John F. Angeline, Arthur D. Little, Inc., 30 Memorial Drive, Cambridge, Mass.; **Ames section,** Dr. Emerson Bird, Dairy Chemistry Department, Iowa State College, Ames, Iowa; **Chicago section,** Louis G. Buettner, Ac'cent International, 20 N. Wacker Dr., Chicago 6, Ill.; **Dixie section,** William B. Cown, Georgia Institute of Technology, Engineering Experiment Station, Atlanta, Ga.; **Texas section,** M. A. Cross, Foremost Dairies, Inc., 1220 Smith St., Houston, Tex.; **Northern California Fresno sub-section,** Edward J. Derderian, Elliott Mfg. Co., 1735 Ventura Ave., Fresno, Calif.; **New York section,** Charles E. Flynn, General Foods Corp., Central Labs Division, Eleventh & Hudson Sts., Hoboken, N. J.

Ohio Valley section, Eugene G. Grab, Jr., Heckin Can Co., Park & Forest Aves., Norwood 12, Ohio; **St. Louis section,** Charles M. Harrold, Jr., 215 Rosemont Ave., St. Louis 19, Mo.; **Mohawk Valley section,** Dr. Theodore F. Irmiter, "Junket" Brand Foods, Little Falls, N. Y.; **Florida section,** Robert W. Kilburn, Director of Research, Florida Citrus Canners Corp., Lake Wales, Fla.; **Philadelphia section,** William Knightly, Atlas Powder Co., Wilmington 99, Del.

Ak-Sar-Ben section, Kenneth R. Kuhlman, 330 Midland Dr., Council Bluffs, Iowa; **Wisconsin section,** Russell H. Maas, 5501 Goucher Lane, Madison 4, Wis.; **Southern California section,** Gordon L. Merchant, Merck & Co., Inc., 1855 Industrial St., Los Angeles 21, Calif.; **Australia Northern section,** F. Peter Muller, c/o Box 14, Post Office, Burwood, N. S. W., Australia; **Hawaiian section,** Dr. Charles E. Mumaw, Hawaiian Pineapple Co., P. O. Box 3380, Honolulu 1, Hawaii.

Northern California section, Robert L. Olson, Western Utilization Research and Development Division, U. S. Dept. of Agriculture, 800 Buchanan St., Albany 10, Calif.; **Great Lakes section,** Prof. William F. Robertson, Department of Horticulture, Michigan State University, E. Lansing, Mich.; **Indiana section,** Alfred P. Rumminger, Bessire and Co., Inc., 101-119 E. South St., Indianapolis 9, Ind.; **Delta sub-section,** Miss Marion J. Simone, Department of Food Technology, University of California, Davis, Calif.; **Western New York section,** Stanley Skelskie, Loblaw, Inc., 692 Bailey Ave., Buffalo 5, N.Y.

Puget Sound section, John Spinelli, 7966 Seward Park Ave., Seattle 18, Wash.; **Kansas City section,** A. E. Stevenson, 2009 Tennessee St., Lawrence, Kan.; **Maryland section,** LeRoy V. Strasburger, 1403 Eutaw Pl., Baltimore 17, Md.; **Pittsburgh section,** V. Walter Vaurio, Applied Research Laboratory, U. S. Steel Corp., Monroeville, Pa.; **British Columbia section,** J. L. Walter, Kelly, Douglas & Co., P. O. Box 39, Vancouver 1, B.C.; and **Minnesota section,** George C. Youland, Green Giant Co., 1100 Summitt St., Le Sueur, Minn.

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IFT News

Open House for Science Students Held at Rutgers

On Friday, November 22nd, at Rutgers University, the Food Technology Department held an "Open House" for all the senior high school science students in the state of New Jersey. The purpose was to show the students what kind of equipment the Department has and what they do, with the idea that students might choose this field instead of straight chemistry or straight engineering. Twenty-three high schools accepted the invitation and over 600 students and teachers were in attendance. "The place was mobbed," reports Department head, Walter A. Maclinn, "and we were all very happy to have it so."

Prior to the "Open House" the food companies, hotels, restaurants, etc. of the state were contacted to see if they were interested in financing the expenses of the students from their local high schools. The following companies cooperated on this basis: American Cyanamid Company, Food Fair Stores, Inc., Fiddler's Creek Farm, Hoffmann-La Roche, Inc., Jugtown Mountain Smokehouse, Kellner Provision Company, Inc., Thomas J. Lipton, Inc., The B. Manischewitz Company, McGraw-Hill Publishing Company, Merck & Company, Inc., Molly Pitcher Hotel, Monmouth Cold Storage Company, Moore & Company, Soups Inc., Nat Pack of N.J., Inc., Preservaline Manufacturing Company, Refined Syrups & Sugars, Inc., Rosedale, Inc., Seabrook Farms Company, R. S. Watson & Son, U. S. Naval Research Facility.

High school science students were attentive listeners when Rutgers' Food Technology Department's miccrowave heater was explained and demonstrated.

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Phi Tau Sigma

The University of Massachusetts Chapter of Phi Tau Sigma, the honorary society for food science, has elected to membership in the Society the following members of the university staff: Marilyn B. Derby, instructor in home economics, Ward M. Hunting, instructor in food technology, Donald N. Maynard, instructor in olericulture, Jane McCullough, assistant professor of home economics, Louis F. Michelson, assistant in olericulture, Franklin W. Southwick, professor of pomology and John H. Vondell, associate professor of poultry husbandry. Also elected was Frederick A. Siino, Amherst Board of Health Agent, and part-time graduate student in food technology.

Chapter officers elected for 1958 were: president—Dr. R. B. Read (Bacteriology), vice president—Prof. G. B. Snyder (Olericulture), secretary—Dr. W. S. Mueller (Dairy Industry), Treasurer—D. R. Lambert (Food Technology), and national councillor—Dr. W. Averill (Food Technology).

Dr. F. J. Francis, executive secretary of the society, which was founded at the University of Massachusetts in 1953 and whose national headquarters are perma-

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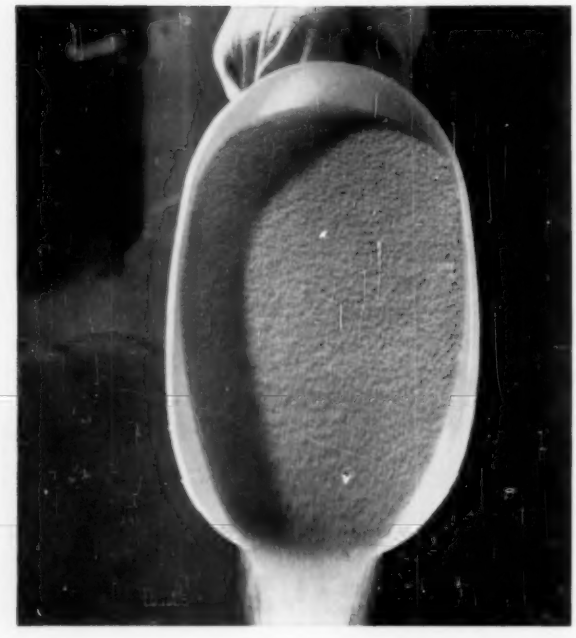

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nently located there, announced the establishment of a new chapter at the University of Wisconsin in Madison, Wisconsin. This brings the number of chapters to seven, the other six being located at the University of Massachusetts, Rutgers University, the Massachusetts Institute of Technology, the University of Georgia, Cornell University, and Michigan State University.

Professor Emil Mrak, National President of Phi Tau Sigma

The elective national officers for the current year are: Professor Emil M. Mrak of the University of California, president, Professor Samuel A. Goldblith of M.I.T., vice president, and Dr. Robert E. Buck of the H. J. Heinz Co., secretary-treasurer.

REGIONAL NEWS

CHICAGO

The Annual Party and Ladies Night was held Monday, December 9, 1957 at the Midland Hotel. There was an excellent turnout. The occasion was not only highlighted by holiday good fellowship but also by an excellent speech by Dr. Henry L. Cox, formerly vice president of the Corn Products Refining Company and presently a consultant. Dr. Cox holds degrees in chemistry and chemical engineering from the University of North Carolina and the University of Chicago. Dr. Cox revealed the techniques of making synthetic gems, illustrating his talk with kodachrome slides. The national officers of IFT, present in Chicago for their mid-year meeting, were in attendance. President Emil Mrak spoke briefly to the 170 members and friends gathered for the occasion.

AUSTRALIA N.

Two distinguished visitors from overseas were Australian guests this fall.

In September Colonel C. S. Lawrence, IFT Executive Secretary, spent several days with us. The Colonel arrived at Kingsford Smith Airport on the 18th of September where he was met by his Australian Northern Section hosts and escorted to the Hampton Court Hotel which commands a delightful view of the harbour. On the 19th he was taken on a tour of Sydney's southern beaches. In the evening he was entertained at a dinner at the Hermitage Restaurant in Manly. Friday, September 20 was spent at the University of Technology with Professor Reuter as host. On that day also, he visited the CSIRO Laboratories at Homebush and in the evening addressed a group of some 40 members. A tour of the Northern

Oil, vinegar, spice flavors—
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You would know better than we whether there is any future in this idea.

The cruet contains 10% of water. It might have been vinegar. The rest is oil. Half of the oil is the usual triglyceride salad oil. The other half of the oil is distilled monoglyceride. It is equally wholesome food. The monoglyceride dissolves both the conventional salad oil and the water. This clear, uniform, stable solution can carry both oil-soluble and water-soluble condiments and flavor extracts.

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beaches was made on Saturday with lunch at Jonah's Restaurant on Whale Beach. On Sunday, 22 September, the Colonel was driven to Canberra with a picnic lunch enroute. This trip allowed an impression of the rural area of New South Wales. As a memento of his visit the Colonel was presented with an original Albert Namatjura, the painting being of some typical Australian gums in the Todd River area.

Also visiting Australia is Dr. George F. Stewart, Chairman of the Poultry Husbandry Department, University of California, Davis. In October Dr. Stewart addressed a conjoint meeting of the Dietitians Association and IFT at the Food School, East Sydney Technical College. His discussion centered on recent developments in methods of preserving meat products in the U.S.A. Dr. Stewart presented some interesting new experimental work, including the radiation preservation work now being widely studied in the United States.

N. CALIFORNIA

The Annual Meeting of the Northern California Section was held December 5 and an outstanding set of papers was presented. Discussed during the day-long session were: *dehydration problems*, with three papers—one by R. L. Hughes, another by C. O. Chichester, and a third by George K. Notter and his colleagues D. H. Taylor and J. E. Brekke; *enzymes*, with talks by W. J. Ferracone, M. J. Powers, and J. R. Whitaker; *radiation preservation*, presented by Roger Romani, Luis Duran and Al Tappel; *bacteriology*, with two papers, one by Reese Vaughn and associate authors from the University of Sao Paulo, Brazil and another by Bernie Feinberg; *chemistry*, with papers by Harold S. Olcott, Frank Lamb, and by Francis F. Wong and J. F. Carson; *food manufacture*, with four presentations, the first by George Carlin, the second by J. A. Finley, the third by Allan D. Shepherd and H. J. Neuman, and the fourth by Norma J. Downes and M. J. Powers; *consumer acceptance*, with a paper by Rose Marie Pangborn on factors influencing consumer opinion.

In addition to this coverage, professionalism for the food technologist was discussed by Dave Eolkin, the re-use of water in washing fruit by Walter A. Mercer, the simple hygrometer by Glenn Watters and J. E. Brekke, and a technical reference file system by G. A. Pitman. Under this file system 1400 classifications are possible on a 3 x 5 card.

Mr. William Harvey, Department of Agronomy, University of California, Davis, was the banquet speaker. He presented a humorous talk dealing with weed killers.

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S. CALIFORNIA

SCIFTS combined forces with the Cereal Chemists in November in order to avail themselves of the opportunity of hearing Dr. Thomas J. Schoch discuss Starch Chemistry and the Uses of Starch in the Food Industries. Unfortunately, the flu bug decimated the numbers and only two-thirds of the reservations were picked up. Dr. Schoch, who has been with Corn Products Refining Company since 1937, very capably explained why starch behaves as it does and how one might direct it to accomplish a given purpose. His discussion centered on granules, pastes, and films. Properties of granules of interest to the user he listed:

1) State of aggregation
2) Ionic charge—this is especially important in textiles
3) Gelatinization temperature
4) Rate and extent of granule swelling
5) Rate and extent of solubilization during swelling. In this respect it was pointed out that corn and waxy sorghum show two stages of swelling.

The properties of starch paste to consider include:

1) Viscosity during cooking and cooling

INSIDE SCIENCE

The Vital Story of Vitamin B_1

(Thiamine)

by Science Writer

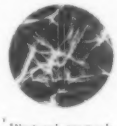
History. The discovery of vitamin B_1 resulted from research into the cause of beriberi. Almost 50 years passed between Eijkman's discovery of the relationship of the disease to diet and the famous work of Jansen and Donath who first isolated the crystalline vitamin from rice bran.

Within ten years of that first isolation the vitamin's chemical structure was determined and it was successfully synthesized.

Eijkman's work resulted in the development of a theory that beriberi was caused by a lack of some factor in the diet and not by a toxin or infectious agent. This idea was not readily accepted until the growth of dietary knowledge proved it correct.

Isolation and Synthesis. In 1926 Profs. Jansen and Donath accomplished the isolation of crystalline vitamin B_1 from rice bran. In 1931 Windaus and co-workers successfully isolated pure vitamin B_1 and established its empirical formula.

In 1936 R. R. Williams, and independently R. Grewe, explained the vitamin's chemical structure. That year, R. R. Williams and J. K. Cline accomplished the synthesis of thiamine which is in wide use today. Andersag and Westphal also synthesized the vitamin in 1936. Another synthesis was described by Bergel and Todd in 1937.



Photomicrograph of B_1 crystals

Chemical and Physical Properties. Thiamine hydrochloride is white, water soluble, with a nut-like, salty taste and yeast-like odor. Its empirical formula is: $C_{12}H_{17}ClN_4OS \cdot HCl$. Thiamine produced by synthesis is identical chemically and in biological activity with that obtained in pure form from nature.

Deficiencies. A deficiency of thiamine is characterized by these symptoms: depression, irritability, fearfulness, lack of initiative and interest, loss of appetite. Symptoms vary since in usual practice deficiencies of other water-soluble vitamins occur. Medical treatment is simple: a sufficient amount of thiamine is administered to relieve symptoms quickly and the physician provides for a continuing adequate intake.

Beriberi victim

A severe deficiency of thiamine leads to beriberi, a serious and sometimes fatal disease. While beriberi is almost a medical curiosity in the United States, it is common in countries in which polished white rice is a staple of the diet.

Human Nutrition Requirements. Thiamine is one of the nutritive elements the human body needs daily and does not store in quantity. The minimum daily requirements established by the U. S. Food and Drug Administration for the prevention of symptoms of thiamine deficiency disease are:

Adults	1.00 mg.	Children (1-5 incl.)	0.50 mg.
Infants	0.25 mg.	Children (6-11 incl.)	0.75 mg.

The Food and Nutrition Board of the National Research Council recommends the following dietary intake of thiamine for healthy persons in the U. S. A.

Recommended Daily Intake in Milligrams

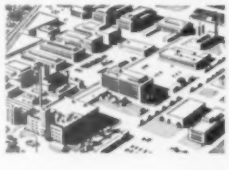
Age	*Men*	*Women*
25	1.6	1.2
45	1.5	1.1
65	1.3	1.0
Pregnant (3rd trimester)		1.5
Lactating		1.5

The Council recommendations for infants and children vary below and above these figures, based on age and sex. Various illnesses and stress situations can exhaust vital reserves of thiamine. So, for the physician, vitamin B_1 is prepared in various dosage forms and potencies for therapeutic and prophylatic use.

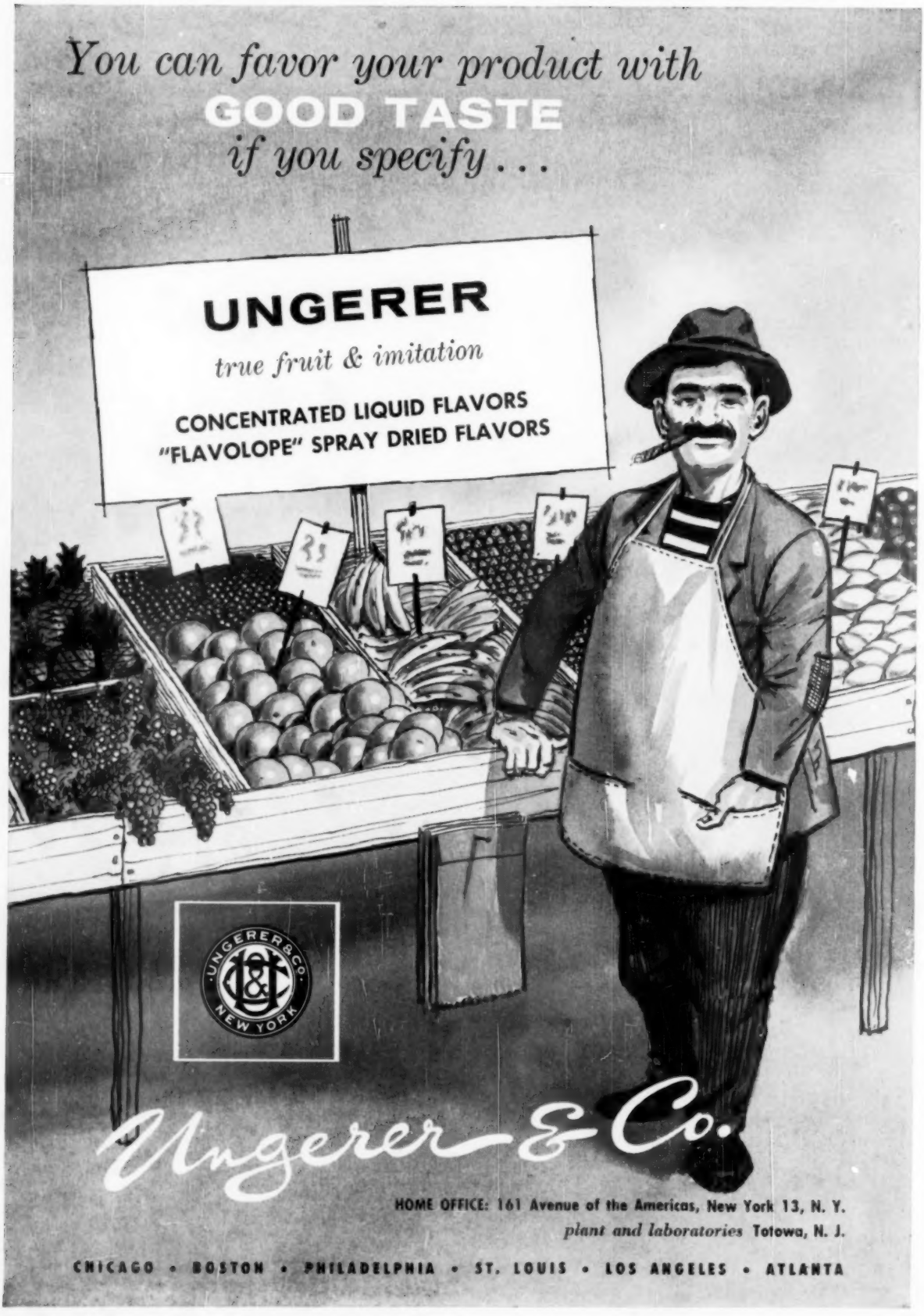
How do human beings receive thiamine? It is widely distributed in foods of animal and vegetable origin, particularly cereal grains and dry legumes. Because of public demand for refined products which millers must meet for obvious economic reasons, a loss of thiamine and other factors occurs during processing. The thiamine loss is overcome through the use of *enrichment* in cereal grain products for which Federal Standards exist, or in other foods such as breakfast cereals, by *fortification* or *restoration*. When enriching, fortifying or restoring, the food processor adds the necessary amount of pure thiamine (and other vitamins and minerals) to the food so that the finished product meets Federal, state and territorial requirements or contributes to the consumer an amount of the vitamin which dietary experts believe significantly useful.

Thiamine is extensively used for the enrichment of cereal grain foods such as white flour, white bread and rolls, macaroni products, farina, corn grits and meal, milled white rice. The story of these uses is delightfully told in a separate brochure which is available on request for reference or educational purposes.

Production. Huge production facilities at the Hoffmann-La Roche plant in Nutley, New Jersey, deliver highest quality thiamine *by the tons*. Roche manufactures thiamine hydrochloride and thiamine mononitrate. These fine products, which equal or exceed U.S.P. specifications, are ideal for use by pharmaceutical makers and food processors. Years of experience in research and manufacture have made Roche the leader in vitamins.



This article is published in the interests of pharmaceutical manufacturers, and of food processors who make their good foods better with essential, health-giving vitamin B_1. Reprints of this and others in the series are available on request. Write the Vitamin Division, Hoffmann-La Roche Inc., Nutley 10, New Jersey. In Canada: Hoffmann-La Roche Ltd., 1956 Bourdon Street, St. Laurent, P. Q.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Quantity of Sample, Swallowing, and Rinsing Factors in Flavor Preference Testing of Tomato Juice[a]

L. A. Pettit[b]

Food Technology Department, Oregon State College, Corvallis, Oregon

(Manuscript received June 15, 1957)

THE PHYSIOLOGICAL COMPONENT in a flavor judgment suggests the possibility that certain effects might be anticipated in taste testing due to the amount of the sample consumed, swallowing or not swallowing the product, or rinsing of the mouth between tastes. Beidler *(1)*, Morgan *(10)*, Pfaffman *(11)*, and others, have pointed up the physiological complexity of a taste response. Woodworth *(14)* reports work indicating the suppression of taste sensitivity by the holding of sugar solutions and, to a lesser extent, quinine solutions in the mouth. Engel *(4)* has indicated changes in pleasantness or unpleasantness of taste responses with varying concentrations of sugar, acid, salt, or quinine solutions.

There appear to be some differences of opinion on the merits of rinsing or swallowing in conducting various flavor tests. Studies reporting the effects of swallowing and rinsing have dealt primarily with flavor difference testing. Crocker, Sjöström and Tallman *(3)*, Moncrieff *(9)*, and Platt *(12)* have reported that it is better for taste judges to eject samples rather than to swallow them. Lorant *(6)*, as well as Moncrieff and Platt, have recommended that lukewarm water be used for rinsing the mouth between samples. Gaebe *(5)* and McCammon, Pittman and Wilhelm *(7)* suggested that the tongue be wiped with a napkin followed by a water rinse in testing of egg products. Crocker *(2)* expresses the opinion that rinsing of the mouth is usually not necessary or desirable, except after tasting clinging substances. Trout and Sharp *(13)* suggest that tasting a poor-flavor sample without having previously rinsed the mouth may produce discrepancy in results. Other workers have considered that rinsing was not helpful in their taste tests *(8)*.

Effects of swallowing, rinsing, and the amount of sample were the focus of this series of flavor preference tests conducted with commercially packed tomato juice. It was desired to know whether results obtained from college student preference panels would be altered by variation in these factors.

EXPERIMENTAL PROCEDURE

Rinsing the mouth with tap water between tastes. To examine rinsing, 6 pairs of one-ounce samples of tomato juice were presented in random order to each taster of a panel of 134 college students. One cup of each of the pairs was identified as reference sample by R. The other cup was identified only by a 4-digit code number. Three of the 6 pairs of samples consisted of identical tomato juice. The coded cup of the other 3 pairs contained the same tomato juice as the identical pairs, whereas the reference cup of these 3 pairs contained tomato juice of a different brand which preliminary tests had determined to be of a different preference.

A 7-point, word-phrase preference ballot containing specific instructions concerning the rinsing of the mouth with tap water was issued with each pair of samples. Three types of ballots were constructed. Ballot 1 instructed the taster to be sure to rinse his mouth with tap water between tasting the reference and the sample. Ballot 2 instructed the taster not to rinse his mouth with water between tasting the reference and the sample. Ballot 3 instructed the taster to use his normal tasting procedure in arriving at his preference judgment. The order of presenting the ballots was randomized.

Normal tasting procedure with respect to rinsing was ascertained by a written poll of the tasters obtained from each immediately following his tasting. The poll asked the question, "Do you rinse with water between tastes in your normal procedure of tasting tomato juice?" to which in most cases the answer was a direct "yes" or "no". In a few cases the tasters responded with "sometimes" or "yes and no". One hundred and five tasters of this panel of 134 stated they did not normally rinse in tasting tomato juice; 20 stated they did normally rinse in tasting tomato juice.

These tests were conducted in individual tasting booths lighted uniformly by white incandescent light. Each booth was equipped with a stool, a service counter, a pencil, paper rinsing cups, and an individual porcelain basin having hot and cold water supply. Tap water for rinsing was turned on in advance of the tests, was left running during the tests, and was maintained at a temperature of 50° to 55° F. throughout the test by checking at intervals with a thermometer.

Swallowing the product. In order to determine the effect of swallowing the product on findings of the flavor preference panel, 4 pairs of one-ounce samples of tomato juice, in small paper cups, were presented to each taster of a panel of 123 college students. Tasters were seated for the test in individual taste testing booths as described above. Each pair of samples was served on a metal tray passed to the taster through a sliding-door opening which was then closed during the tasting.

One sample of each pair was identified as a reference sample by R, the other was identified only by a 4-digit code number on the cup. Two of the 4 pairs presented contained identical tomato juice. The reference sample of each of the other 2 pairs consisted of tomato juice of a different brand than the accompanying coded samples which was the same juice as the identical pairs.

A 7-point printed preference ballot containing specific instructions was given to each taster with each pair of samples. These ballots were of 2 types. One instructed the taster to be sure to swallow the juice each time the reference and the sample were tasted. The other instructed the taster to place the juice in his mouth, and then to discard it from the mouth into the basin before making his judgment. The ballot in each case instructed the taster to indicate his preference judgment by writing the number of the coded sample in an appropriate space in the column provided.

---

[a] Technical Paper No. 1030, Oregon Agricultural Experiment Station.

[b] Present address: Home Economics Department, University of Utah, Salt Lake City, Utah.

One of the 2 types of ballots was presented with one of the identical pairs; the other was presented with the other identical pair. Likewise, the 2 types of ballot were presented with the 2 non-identical pairs of tomato juice samples. The order in which the 4 pairs was presented to each taster was randomized.

Quantity of sample consumed by taster. The quantity of sample consumed as a factor in flavor preference was examined by conducting 2 separate tests. In the first of these, 3 pairs of tomato juice samples in paper cups were presented to each taster of a panel of 135 men and women college students. In the second test, 3 pairs of samples were presented to 67 men and women college students. The tasters were seated for the tests in the individual taste testing booths previously described. Each of the pairs of samples was served on a separate tray passed to the taster through an opening in the booth which was then closed. One cup of each pair of samples was identified as the reference by R. The other cup was identified only with a 4-digit code number chosen from a random number table.

Each cup of reference contained 1½ ounces of tomato juice. The coded cup in 2 of the 3 pairs contained 1½ ounces of juice; the coded cup of the third pair contained one-half ounce of juice. In the first test, all tomato juice for all of the cups was identical, obtained from one lot, prepared by blending the contents of several 46-ounce cans into a single container for service into the sample cups. In the second test, all reference cups contained tomato juice of one brand, while all coded cups contained juice of another brand. Preliminary tests had determined that these 2 brands were of different flavor preference.

A 7-point, printed preference ballot containing specific instructions was presented with each pair of samples. These ballots were of 2 types. One instructed the taster to be sure to consume all of the juice in the coded sample cup before rendering his preference judgment. This ballot was presented with one of the pairs of samples consisting of 1½ ounces of juice in both the reference and the coded cup. It was also presented with the pair of samples which consisted of 1½ ounces of juice in the reference cup and one-half ounce of juice in the coded cup.

The other ballot instructed the taster to drink whatever amount of the sample he desired before making his preference judgment. This ballot was presented with one of the pairs of samples containing 1½ ounces of tomato juice in both the reference and the sample cups. The order in which the 3 pairs of samples of juice was presented to each taster was randomized.

Determination was made of the average amount of juice consumed by each taster on the basis of the ballot instructions to drink whatever amount of the sample he desired. This optional amount was found to average 1.1 ounces per taster in the case of each of the tests. Unused juice remaining in the coded cups was collected, measured for total volume at the end of the testing day, and the average amount consumed per taster calculated according to the number of tasters in the panel.

ANALYSES AND RESULTS

Rinsing. In the case of all tests, the judgments obtained from the tasters were transposed to numerical scores on a 7-point scale in which 1 represented *much poorer flavor than reference*, 2 represented *moderately poorer flavor*, 3 represented *slightly poorer flavor*, 4 represented *neither better nor poorer flavor*, 5 represented *slightly better flavor*, 6 represented *moderately better flavor*, and 7 represented *much better flavor than reference*. Scores obtained for the 6 coded samples in the rinsing tests were tabulated and analyzed statistically by analysis of variance on the basis of a 2 x 3 x 134 factorial design. This enabled determination of whether the panel preference differed as a result of the 3 rinsing variables in relation to either of the references. It also permitted determination of whether the scores were different with respect to the 2 references.

The analysis of variance, Table 1, reveals that the mean scores of the coded samples with relation to the two references were significantly different. The mean scores with respect to rinsing, not rinsing, or normal rinsing procedure, Table 2, were not, however, significantly different. Some individual tasters differed in their preference judgments, and tasters reacted differently with respect to the 2 reference samples, as indicated by the significant interaction between tasters and reference. On the other hand, rinsing procedures uniformly lacked effect on tasters as evidenced by non-significant interaction between tasters and rinsing procedures. Likewise, rinsing procedures had no effect irrespective of the reference, as shown by no significant interaction between reference and rinsing.

TABLE 1

Effect of rinsing between tastes
Analysis of variance

Variation source	Degree of freedom	Mean square	F
Reference	1	22.3334	9.34**
Rinsing	2	1.2028	1.09
Reference x Rinsing	2	2.4042	2.17
Tasters	133	2.2739	2.05**
Tasters x Reference	133	2.3910*	2.16**
Tasters x Rinsing	266	1.2817	1.16
Error	266	1.1085	.....
Total	803	.....	

*Error term for Reference.
**Significant at 1%.

Swallowing. Scores obtained in the swallowing tests were tabulated on the basis of swallowing or not swallowing the identical and the non-identical samples, designated as samples K and samples A, respectively. These scores were then statistically analyzed for variance.

TABLE 2

Effect of rinsing
Mean scores of coded samples (134 tasters)

Performance	Sample identical to reference	Sample different from reference
Rinsing between tastes	4.10	4.37
Not rinsing between tastes	4.12	4.30
Normal rinsing procedure	3.84	4.38
Means per reference	4.02	4.35

The analysis of variance, Table 3, reveals that scores for sample K and sample A were significantly different when swallowing, but not significantly different when not swallowing. This indicates that when the product was swallowed the tasters were discriminating between the samples, but when it was not swallowed the tasters did not discriminate. The mean scores are shown in Table 4.

Inasmuch as the true value for the K samples is known to be 4, the t-test was applied to ascertain whether the scores obtained for K were significantly different from the true score. The "t" value in the case of swallowing the sample is 1.48, which is not

TABLE 3

Effect of swallowing the product
Analysis of variance

Variation source	Degree of freedom	Mean square	F
Tasters	122	1.9811	1.55**
Swallow vs. Not Swallow	1	1.8293	1.43
Swallowing, K vs. A	1	6.8334	5.33*
Not Swallowing, K vs. A	1	0.9147	0.71
Error	366	1.2820	.....
Total	491	.....	

*Significant at 5%.
**Significant at 1%.

significant. In the case of not swallowing, however, the "t" value is 2.56, which is significant at the 5% level, signifying that the panel score was significantly different from the true value of 4 when not swallowing.

Quantity of sample. Scores obtained from the tasters for the 3 coded samples in each of the quantity tests were tabulated on the basis of the 3 different quantities of identical juice consumed and were analyzed for variance.

The analysis of variance for each of the 2 tests conducted, Tables 5 and 6, reveals that the effect of the quantity of juice consumed was clearly significant. Mean preference scores obtained in the 2 tests are given in Table 7.

TABLE 4

Effect of swallowing
Mean scores of coded samples (123 tasters)

Samples	Swallowing	Not swallowing
K (identical to R)	4.15	4.26
A (different from R)	4.49*	4.14

* Difference between K and A when swallowing is significant at 5%.

In order to determine which of the quantities consumed produced the most accurate result, a t-test for the difference between the true score and the panel scores was made in the case of the samples identical to the reference. This could be done inasmuch as the true score for preference between identical samples is 4.00 on the scale used, representing neither better nor poorer flavor. The true preference score for the non-identical samples was not known.

The "t" values obtained were 2.13 in the case of one-half ounce of juice consumed, significant at 5%, 2.23 for the average of 1.1 ounces of juice consumed, significant at 5%, and 1.38 for the case of 1½ ounces of juice consumed, which is not significant. These values indicate that the panel scores for samples identical to the reference differed significantly from the true score in the case of each of the two smaller quantities consumed. Only in the case of the largest quantity consumed was the score not significantly different from the true value.

TABLE 5

Effect of quantity of sample consumed
Test A—samples identical to the reference

Variation source	Degree of freedom	Mean square	F
Quantity	2	6.4395	5.40**
Tasters	134	1.5182	1.27*
Error	268	1.1932	.....
Total	404	.....	

*Significant at 5%.
**Significant at 1%.

TABLE 6

Effect of quantity of sample consumed
Test B—samples different from the reference

Variation source	Degree of freedom	Mean square	F
Quantity	2	43.0050	25.65**
Tasters	66	2.7525	1.64**
Error	132	1.6767	.....
Total	200	.....	

**Significant at 1%.

SUMMARY AND CONCLUSIONS

These findings show that rinsing or not rinsing with tap water did not influence the preference results of the panel for the tomato juice tested. This result was obtained for samples identical with the reference as well as for samples judged by the panel to be different from the reference. In the absence of interaction between the reference samples and the rinsing procedures, it is evident that rinsing or not rinsing had no effect on this panel preference irrespective of the 2 types of reference used.

Results of the swallowing tests indicate that swallowing as compared to not swallowing clearly influenced the preference findings of the panel for this product. Swallowing the tomato juice resulted in a true preference score, whereas not swallowing produced an untrue preference score for samples which were identical to the reference. Swallowing also enabled the tasters to discriminate between samples which were different. This suggests that in the absence of swallowing, preferences for samples which are different from the reference may also be untrue.

TABLE 7

Effect of quantity of sample consumed
Mean scores of coded samples

Quantity consumed	Test A samples identical to R	Test B samples different from R
0.5 ounce	3.80	3.09
1.1 ounces	4.21	4.61
1.5 ounces	4.13	4.28
Number of Tasters	135	67

Analyses of the quantity tests indicate clearly that the preference judgment of the panels was influenced by the quantity of tomato juice consumed, whether or not the sample tasted was the same or different from the reference. The correctness of the judgments rendered by the panel for the samples which were different from the reference could not be ascertained in view of the lack of a known true value. But in the case of the samples which were the same as reference, it is seen that only the largest amount consumed—1.5 ounces by each taster—produced a true panel preference result. This would suggest that in the conduct of such tests care should be taken to see that tasters consume an adequate quantity of sample.

It is concluded that, with respect to the preference for tomato juice by these college student panels, (1) rinsing the mouth with tap water between tastes has no effect on the preference expressed by the flavor panel; (2) swallowing the product produces more accurate preference results than not swallowing it; (3) flavor panel preference is altered by the quantity of sample consumed by the taster. A larger quantity consumed apparently produces truer results than a smaller quantity consumed.

LITERATURE CITED

1. Beidler, L. M. Our taste receptors. *Scientific Monthly*, **75** (6), 343–349 (1952).
2. Crocker, E. C. Flavor. 1st Ed. 1945. McGraw-Hill, New York, N. Y.
3. Crocker, E. C., Sjöström, L. B., and Tallman, G. B. Measurement of food acceptance. *Ind. Eng. Chem.*, **40**, 2254–2257 (1948).
4. Engel, R. Experimentelle Untersuchungen über die Abhangigkeit der Lust and Unlust von der Reizstarke beim Geschmackssinn. *Archiv f. d. gesamte Psychologie*, **64**, 1–36 (1928). (Abstracted in *Psychological Abstracts*, **3**, 1051, 1929).
5. Gaebe, O. F. A comparative odor and flavor study of eggs stored in avenized and unavenized fillers and flats. *U. S. Egg and Poultry Magazine*, **46**, 346–349 (1940).
6. Lorant, J., and Lorant, G. Taste test procedure. (Mimeo.) Food Technology Department, Oregon Agricultural Experiment Station. (1948).
7. McCammon, R. B., Pittman, M. S., and Wilhelm, L. A. The odor and flavor of eggs. *Poultry Sci.*, **13**, 95–101 (1934).
8. Moncrieff, R. W. Relative sweetness. I. Flavours, fruit juices and spices review, **11** (5):5–6, 8 (1949).
9. Moncrieff, R. W. The choice of flavour. *Food Manuf.*, **22**, 113–118 (1947).
10. Morgan, C. T. *Physiological Psychology*. 1st Ed. 1945. McGraw-Hill, New York, N. Y.
11. Pfaffman, C. Gustatory afferent impulses. *J. Cellular Comparative Physiol.*, **17**, 243–248 (1941).
12. Platt, W. Rational methods of scoring food products. *Food Inds.*, **3**, 108–111 (1931).
13. Trout, G. M., and Sharp, P. F. The reliability of flavor judgments, with special reference to the oxidized flavor of milk. New York State Agricultural Experiment Station. (1937).
14. Woodworth, R. S. *Experimental Psychology*. 1938. Henry Holt and Company, New York, N. Y.

The Kinetics of Bacterial Inactivation by Heat[a,b]

(Manuscript received June 20, 1957)

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It has been noted for many years that bacteria exhibit a logarithmic survival curve when exposed to heat (Figure 1). There has been considerable conjecture about the reason for the shape of the survival curve. The theory for the survival curve is important in determining the theoretical soundness of thermal process evaluation concepts *(1)*.

Distribution of resistance theory. One explanation is that there exists in any bacterial population a distribution of individual physical resistances to heat among the bacterial population. Assume the resistance to thermal destruction can be measured by the amount of time a bacterial cell can withstand exposure to a given temperature. Then the distribution of resistance in a bacterial population must be represented by a skew-shaped curve in order for the survival curve to be logarithmic as in Figure 1.

The distribution curve represented by Figure 2 may be formed from the survival curve data in Figure 1. The time of survival is considered a measure of the resistance to thermal destruction. In determining the distribution curve a resistance interval of $\triangle t = 0.5$ min. was selected (Table 1 and Figure 2).

The skew distribution curve represented by Figure 2 is not considered likely to occur in biological systems according to Ball *(1)*. Rather, a symmetrical, natural distribution curve is usually associated with biological systems. Thus it appears unlikely that the logarithmic survival curve can be due to a skew distribution of resistance among the bacterial population.

The mutual effect theory. An alternative explanation for the logarithmic survival curve suggests that the greater resistance of spores in higher concentra-

[a] Based on a paper presented before a graduate seminar held in February 1956, Department of Food Technology, Massachusetts Institute of Technology, Cambridge.

[b] Contribution 334, Department of Food Technology, M.I.T.

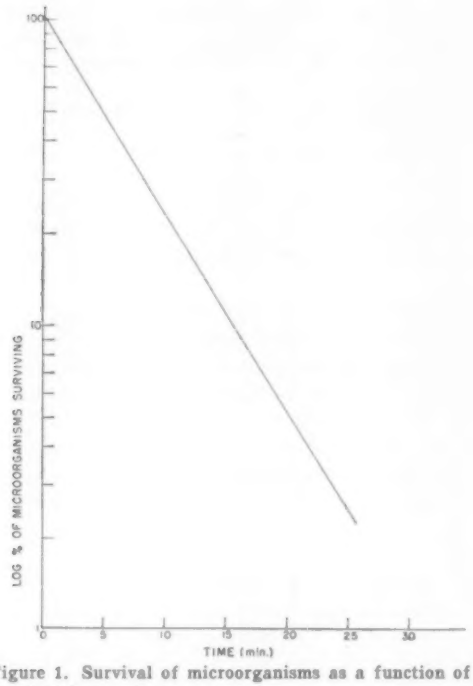

Figure 1. Survival of microorganisms as a function of time at constant temperature.

tion is due to a mutually protective effect among spores when they are in close proximity *(1)*.

The kinetic effect theory. It has long been experienced that any chemical reaction at a given temperature requires a finite time to proceed, even though each individual molecule reacting is believed to be exactly the same. This is explained by considering a distribution of energy among the reacting molecules at a given temperature. The temperature merely measures the median energy level of the molecules present. It is also considered that in order for a molecule to react it must possess a certain minimum amount of energy known as the energy of activation *(4)*.

TABLE 1

Percentage of microorganisms destroyed in a time interval of 0.5 minutes according to the survival curve in Figure 1

$\Delta t = .5$ min. t(min.)	% destroyed	% of microorg. having resistance of t(min.)
0	0	0
0.5	6	6
1.0	13	7
1.5	20	7
2.0	25	6
2.5	30	6
3.0	36	6
3.5	40	5
4.0	45	5
4.5	49	4
5.0	52	4
5.5	56	4
6.0	59	3
6.5	62	3
7.0	65	3
7.5	67	2
8.0	70	3
8.5	72	2
9.0	74	2
9.5	76	2
10.0	78	2

The analogy with bacterial inactivation. In order to draw the analogy with the thermal inactivation of bacteria consider the bacteria cell composed of a number of sensitive volumes surrounded by a number of water molecules, N, (see Figure 3). All this is enclosed within a cell wall. When the water mole-

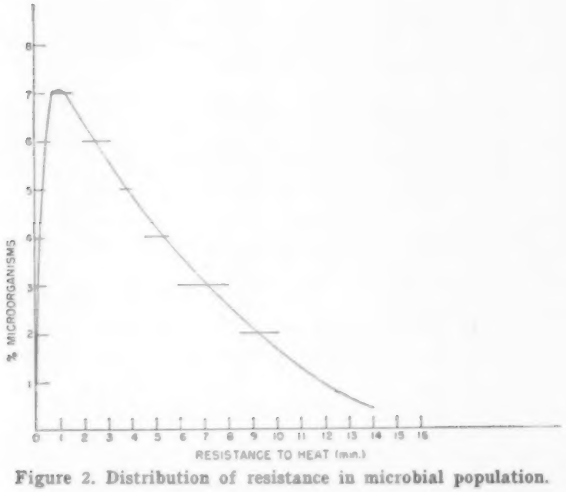

Figure 2. Distribution of resistance in microbial population.

cule, in contact with a sensitive volume, is able to impart sufficient energy to the sensitive volume it is thought to cause inactivation of the cell.

At any given temperature there will be a certain distribution of energy among the water molecules surrounding the sensitive volume. At any time, only a fraction of the water molecules surrounding the sensitive volume will possess the necessary energy to cause inactivation.

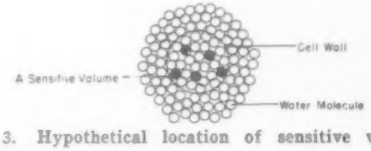

Figure 3. Hypothetical location of sensitive volumes in bacterial spore.

Thus, even though all cells were identical chemically and physically, they would not all be expected to be inactivated at the same time, due to the distribution of energy among the molecules in the cell. The concept of considering energy and temperature on a molecular level with respect to the inactivation of bacteria has also been recognized by Ball and Olson *(2)*.

Determination of number of water molecules possessing inactivation energy. Assume the energy for inactivation which must be imparted to a sensitive volume in a cell is E_a B.t.u. It is possible to calculate, using the Maxwell distribution equation, the fraction of water molecules surrounding sensitive volumes in the population which will possess more than E_a B.t.u. and thus be capable of causing inactivation.

The Maxwell distribution equation is represented by

$$\frac{N_e}{N} = \frac{2}{\sqrt{\pi}} \left(\frac{E_a}{RT}\right)^{1/2} e^{-E_a/RT} \qquad (1)$$

(See Figure 4)

where,

$\frac{N_e}{N}$ = fraction of water molecules, surrounding total sensitive areas in population, possessing more than E_a B.t.u.

R = constant = $2\left(\frac{\text{B.t.u.}}{\text{cell} - {}^\circ\text{R}}\right)$

T = absolute temperature (° R)

E_a = energy of activation, (B.t.u./cell)

The expression $\frac{2}{\sqrt{\pi}}\left(\frac{E_a}{RT}\right)^{1/2}$ is nearly equal one as compared to $e^{-E_a/RT}$ (4). Thus, equation (1) may be approximated by

$$\frac{N_e}{N} = e^{-E_a/RT} \qquad (2)$$

The fraction of water molecules capable of causing inactivation at any time is $\frac{N_e}{N}$. Therefore, the total number of water molecules capable of inactivating a sensitive area at any time must be a $\left(\frac{N_e}{N}\right)$ (N) or $(e^{-E_a/RT})$ (N).

Number of bacterial cells capable of being inactivated at any time. Assume that there are "b" water molecules per cell surrounding sensitive volumes. Assume also that the inactivation of only one sensitive volume in a cell is required for the inactivation of the cell. Then, $(e^{-E_a/RT})\left(\frac{N}{b}\right)$ must be the number of cells which will be inactivated at any time. If $\frac{N}{b} = n$, then d(n) will be the change in the number of bacteria at any time, and therefore

$$d(n) = e^{-E_a/RT}\,(n) \qquad (3)$$

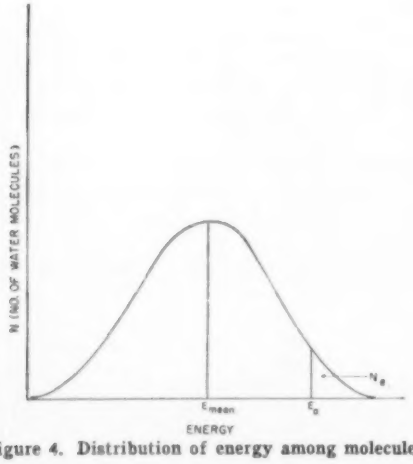

Figure 4. Distribution of energy among molecules.

The frequency of energy transfer. The frequency with which the molecules exchange energy with the sensitive volumes may be designated by the frequency factor, $S\left(\frac{1}{\text{min.}}\right)$. The transfer of energy may be considered to occur through the collision of a vibrating water molecule with a sensitive volume.

The frequency factor S may also be thought of as the frequency with which the energy distribution shifts among the water molecules and hence among the cells.

Since $e^{-E_a/RT}(n)$ is the change at any time, $S\,e^{-E/RT}\,(n)$ will be the change with respect to time.

The differential equation for rate of survival. The change in the number of bacteria with respect to time is $-dn/dt$. The negative sign is used to denote that change is associated with a decrease in number of bacteria. The rate of change is therefore

$$-dn/dt = S\,e^{-E_a/RT}(n) = \frac{\text{(number of microorganisms)}}{\text{min.}} \qquad (4)$$

The logarithmic survival curve. The equation representing the number of survivors with respect to time is found by integrating equation (4), and

$$\ln \frac{n}{n_o} = -S\,e^{-E_a/RT}\,t \qquad (5)$$

or

$$2.303 \log \frac{n}{n_o} = -S\,e^{-E_a/RT}\,t \qquad (6)$$

n_o = initial number of bacteria

n = number of bacteria at time t, and

letting

$$\frac{S\,e^{-E_a/RT}}{2.303} = \frac{1}{D}, \qquad (7)$$

equation (7) becomes

$$\log \frac{n}{n_o} = -\frac{1}{D}\,t \qquad (8)$$

D = the time for the logarithmic survival curve to pass through one log cycle.

Equation (8) is identical with the equation used to describe the logarithmic survival curve encountered in practice.

It is possible, using a kinetic approach, to derive the equation describing the logarithmic survival curve, and therefore it may be that the logarithmic survival curve is due to the kinetics of inactivation.

Calculations and characteristics of inactivation energy E_a. The energy of inactivation may be determined experimentally by plotting $\log \frac{2.3}{D}$ vs. $\frac{1}{T}$, where T is the absolute temperature. The slope of the resulting line is $\frac{-E_a}{2.3R}$ (Figure 5). In Table 4, E_a is tabulated for various temperature ranges and mediums for *Clostridium sporogenes P.A. 3679* and *Clostridium botulinum*. The data used to determine E_a is found in Tables 2 and 3, which were taken from the literature (5).

TABLE 2*

Calculated time for 90% destruction P. A. 3679 spores suspended in various media and subjected to the indicated temperatures

Temp. ° F.	Average D values for P.A. 3679 spores in following products									
	Pureed peas	Strained squash	Whole kernel corn	Uncooked fresh pork	Cooked fresh pork	White sauce	Distilled water	Unsteril. evap. milk	Presteril. evap. milk	Unsteril. 20% cream
220	75.6	32.6	73.4	49.7	58.6	.....	36.9	.....	.....	.....
230	18.8	10.0	16.7	15.6	17.7	.....	10.2	12.7	14.0	15.0
240	5.21	3.02	4.27	.....	4.64	4.16	3.04	4.38	3.84	4.91
250	1.52	0.85	1.18	1.30	1.21	1.23	0.80	.....	1.29	1.52
260	0.347	0.222	.....	0.290	0.319	0.299	0.198	0.457	0.400	0.384
270	0.0860	0.0645	0.0716	0.0924	0.0808	0.0717	0.0496	.....	.....	.....

*Reprinted from *Food Technol.*, 4, 324 (1950).

ILLUSTRATIVE EXAMPLE

From the data in Table 2 determine the energy of inactivation P.A. 3679 in pea puree.

Solution

Degrees Fahrenheit may be converted to the absolute scale or degrees Rankine by adding 460 to degrees Fahrenheit. Thus,

°F.	°R.	$\frac{1}{°R}$	D	$\frac{2.3}{D}$
220	680	.00147	75.6	3.5×10^{-2}
230	690	.00145	18.8	1.23×10^{-1}
240	700	.00143	5.21	4.42×10^{-1}
250	710	.00141	1.52	1.52
260	720	.00139	0.347	6.61

Plotting log 2.3/D vs. 1/°R, the slope of the resulting line is, $\frac{-E}{2.3R} = -12{,}620$, and $E_a = 58{,}250 \frac{\text{B.t.u.}}{\text{cell}}$, Figure 5.

From Table 4, it appears that E_a does not vary in any consistent manner with temperature. It does appear to vary slightly with medium. The energy of activation for chemical reactions is known to be affected by pH *(3)*. It may be for this reason that the medium affects E_a.

The biggest change in E_a occurs between different species of bacteria. For *Cl. botulinum* E_a average varies from $68{,}500 \frac{\text{B.t.u.}}{\text{cell}} - 64{,}500 \frac{\text{B.t.u.}}{\text{cell}}$ and for P.A. 3679, E average varies from $58{,}250 \frac{\text{B.t.u.}}{\text{cell}} - 55{,}500 \frac{\text{B.t.u.}}{\text{cell}}$ (see Table 5). The differences in E_a for different species of microorganisms might be due to pH differences in the cell contents.

Calculation and character of the frequency factor, S. After determining E_a it is possible to calculate the Frequency Factor, S, from equation (7). In Table 4, values of S are tabulated for various temperatures and media.

It is noted that S varies with temperature, and to some extent with media. The value of S may vary 1000 fold between different species.

Change in rate of inactivation with temperature. The increase in rate of inactivation with respect to temperature is due to two factors: a.) the increase in the number of water molecules having an energy of E_a surrounding sensitive volumes; and b.) an increase in the number of collisions per minute of water

TABLE 3*

Calculated time for 90% destruction to Cl. botulinum spores suspended in four different media and subjected to the indicated temperatures

Temp. ° F.	Average D values for *Cl. botulinum* spores in following products			
	Pureed peas	Strained squash	M/15 neutral phosphate	Distilled water
220	10.2	6.92	10.0	5.49
230	1.98	1.79	2.01	1.01
240	0.435	0.393	0.530	0.226
250	0.089	0.060	0.133	0.051
260	0.0203	0.0178	0.0325	0.0131

*Reprinted from *Food Technol.*, 4, 324 (1950).

TABLE 4

Energy of inactivation at various temperature ranges in various media

Medium	Strained peas		Strained squash		Distilled water	
Microorganism	E_a (B.t.u./cell)	Temp. range °F.	E_a (B.t.u./cell)	Temp. range °F.	E_a (B.t.u./cell)	Temp. range °F.
P. A. 3679	58,000	220–230	54,000	220–230	56,500	220–230
	58,250	260–270	55,500	260–270	58,500	260–270
Av.	58,250		55,000		57,500	
Cl. botulinum	71,000	220–230	58,400	220–230	73,500	220–230
	65,900	230–240	65,800	230–240	65,100	230–240
	68,800	240–250	81,800	240–250	64,600	240–250
	64,400	250–260	52,800	250–260	58,700	250–260
Av.	68,500		64,500		65,500	

TABLE 5

Average energy of inactivation for P.A. 3679 and Cl. botulinum various media

Medium	Pureed peas	Strained squash	Cooked fresh pork	White sauce	Distilled water
Microorganism	E_a (B.t.u./cell)	E_a (B.t.u./cell)	E_a (B.t.u./cell)	E_a (B.t.u./cell)	E_a (B.t.u./cell)
P. A. 3679	58,250	55,000	55,000	55,000	57,250
Cl. botulinum	68,500	64,500	.....	.....	65,500

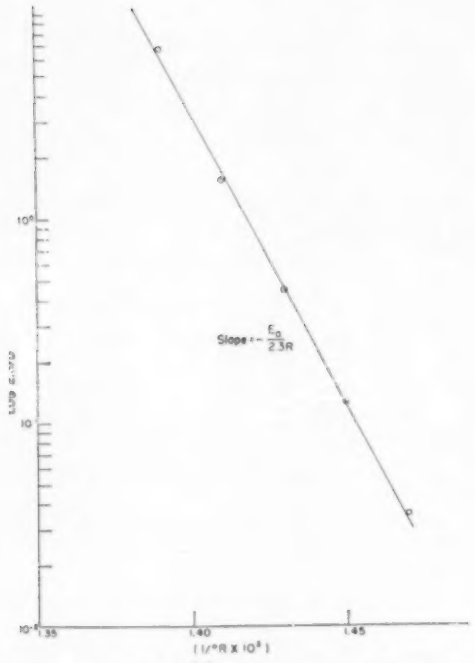

Figure 5. Plot of log $\frac{2.3}{D}$ vs. reciprocal of absolute temperature for calculating energy of inactivation.

molecules with sensitive volumes within the bacterial cell.

Consider the increase in the inactivation rate of P.A. 3679 in pea puree at 270° F. as compared to 220° F.

$$\left(\frac{dn}{dt_{220}}\right) = S_{220}\ (e^{\left[-\frac{58{,}250}{2(220+460)}\right]})\ n$$

and

$$\left(\frac{dn}{dt_{270}}\right) = S_{270}\ (e^{\left[-\frac{58{,}250}{2(270+460)}\right]})\ n$$

from Table 6

$$\frac{S_{270}}{S_{220}} = \frac{6 \times 10^{18}}{1 \times 10^{17}} = 60 = \text{ratio of no. of collisions per min.}$$

$$\frac{(e^{\left[-\frac{58{,}250}{2(270+460)}\right]})}{(e^{\left[-\frac{58{,}250}{2(220+460)}\right]})} = \frac{(N_{E_a})_{270}}{(N_{E_a})_{220}} = \frac{4.46 \times 10^{-18}}{3.15 \times 10^{-19}} =$$

1.42×10^{1} = ratio of activated molecules

Thus

$$\frac{(dn/dt_{270})}{(dn/dt_{220})} = 60 \times 14.2 = 850$$

At 270° F., if n were 10^5 P.A. 3679 spores, the rate of inactivation at that time would be

$$(dn/dt_{270}) = 6 \times 10^{18} \times 4.46 \times 10^{-18} \times 10^5 = 26.8 \times 10^5 \text{ organisms/min.}$$

If n_0 were 10^5 P.A. 3679 spores, after 10 minutes at 270° F. the number surviving, n, would be, according to equation (6),

$$2.3 \log \frac{n}{10^5} = -6 \times 10^{18} \times 4.46 \times 10^{-18} \times 10$$

$$n = 3.15 \times 10^{-112} \text{ microorganism surviving}$$

TABLE 6

Comparison of frequency factor S at various temperatures

Medium	Pureed peas		Strained squash		Distilled water	
Microorganism	S (1/min.)	Temp. (° F.)	S (1/min.)	Temp. (° F.)	S (1/min.)	Temp. (° F.)
P. A. 3679	1×10^{17}	220	2.4×10^{16}	220	1.25×10^{17}	220
	4.45×10^{17}	240	1.57×10^{17}	240	5×10^{17}	240
	2×10^{18}	260	4×10^{17}	260	4×10^{18}	260
	6.0×10^{18}	270	8×10^{17}	270	5×10^{18}	270
Cl. botulinum	1×10^{21}	220	2×10^{20}	220	3.16×10^{20}	220
	4×10^{21}	240	8×10^{20}	240	1.88×10^{21}	240
	1.8×10^{22}	250	2.0×10^{21}	250	4×10^{21}	250
	4×10^{22}	260	4×10^{21}	260	1.26×10^{22}	260

A number of microorganism less than one may be interpreted in terms of most probable number surviving. This concept has been employed by Stumbo and Ball.

Thus, after 10 minutes at 270° F., there is approximately one chance out of 10^{112} chances that a microorganism in the population under consideration would survive. This may also be interpreted as the probability that the sensitive volume in a bacterial cell will escape a fatal collision with a surrounding molecule in this period of time.

This interpretation has importance in the consideration of partial "sterility" concepts in thermal process evaluation methods.

SUMMARY

It is possible, using a kinetic approach, to derive the equation describing the logarithmic survival curve. Therefore, it may be that the logarithmic survival curve is due to the kinetics of inactivation.

The inactivation energy E_a varies with different species of bacteria but is essentially constant with temperature. The pH of the medium may affect the inactivation energy and in this way change the rate of inactivation. The pH is known to affect the inactivation energy of chemical reactions.

The Frequency Factor S varies with temperature and slightly with medium. It changes greatly between different species.

The increase in inactivation rate with increase in temperature is due to the increase in the number of collisions per unit time between surrounding water molecules and sensitive volumes as well as to the increase in numbers of water molecules possessing the energy of inactivation.

LITERATURE CITED

1. Ball, C. O., and Olson, F. C. Foundation of food process calculation methods. *Food Research*, **20**, 666 (1955).
2. Ball, C. O., and Olson, F. C. *Sterilization in Food Technology*. 1957. McGraw-Hill Co., New York, N. Y.
3. Daniels, F. *Outlines of Physical Chemistry*. 1957. John Wiley & Sons, Inc., New York, N. Y.
4. Glasstone, S. *Text Book of Physical Chemistry*. 1951. D. Van Nostrand Co., Inc. New York, N. Y.
5. Stumbo, C. R., Murphy, J. R., and Cochran, J. Nature of thermal death time curves for P.A. 3679 and *Clostridium botulinum*. *Food Technol.*, **4**, 321 (1950).

2-Thiobarbituric Acid Method for the Measurement of Rancidity in Fishery Products

II. The Quantitative Determination of Malonaldehyde[a]

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(Manuscript received August 9, 1957)

THE RED COMPOUND formed by the reaction of 2-thiobarbituric acid with oxidized lipids has been demonstrated to be a measure of the extent of oxidative rancidity in fatty foods. Kohn and Liversedge *(7)* reported that a red color resulted when tissue was incubated aerobically with 2-thiobarbituric acid (TBA). Bernheim, Bernheim, and Wilbur *(1)* postulated that the color described by Kohn and Liversedge was due to a three carbon compound containing an aldehyde or ketone group derived from the oxidation of fatty acids. They reported the same spectral characteristics for the red color. Patton and Kurtz *(11)* subjected a number of compounds to the TBA test. They concluded that malonaldehyde was the compound responsible for the red color maximum at 532 mμ and that this compound was present in oxidized milk fat. In 1951, Patton, Keeney, and Kurtz *(10)* presented additional evidence that the carbonyl compound active in the TBA test and present in rancid milk fat was malonaldehyde. Jennings, Dunkley, and Reiber *(5)* investigated the nature of the red pigment formed by the reaction of TBA with oxidized milk fat, malonaldehyde, and 2-sulfanilamidopyrimidine and found they all exhibited the same spectral characteristics in the visual range.

There have appeared in the literature a number of empirical procedures using the TBA reaction as a measure of oxidative rancidity in a wide variety of food materials; dairy products *(2, 10, 11, 13)*; pork *(14)*; bakery products *(3)*; and oysters *(12)*. Yu and Sinnhuber *(16)* presented a TBA method for the measurement of rancidity in fishery products. This method was performed on the intact sample without fat extraction and the results were expressed in terms of $E^{1\%}_{1cm}$ at 535 mμ. Since that time a sample of 1,1,3,3-tetraethoxypropane (TEP) has become available. This compound when subjected to the TBA procedure described by Yu and Sinnhuber *(16)* hydrolyzes to yield malonaldehyde which reacts with TBA to give the typical red color.

The procedure presented in this report employs TEP as a standard for the TBA determination of malonaldehyde. Acid hydrolysis of TEP yields malonaldehyde which reacts quantitatively with TBA and affords a procedure for the determination of this carbonyl compound. By this method the malonaldehyde content of fishery products may be quantitatively measured and the degree of oxidative randicity expressed in milligrams of malonaldehyde per 1000 g. of sample.

EXPERIMENTAL

Reagents. 1,1,3,3-Tetraethoxypropane. Prepare solutions in 40% ethanol in concentrations from 0.0602 to 0.001 moles.

The remainder of the reagents is the same as previously described by Yu and Sinnhuber *(16)*.

Apparatus. The same as previously described *(16)*.

Procedure. The identical procedure was followed as described *(16)* except that 0.6 N hydrochloric acid was used in place of the pyridine hydrochloride and trichloroacetic acid. After 30 minutes under a reflux condenser, 75 ml. of 0.6 N hydrochloric acid was added through the top of the condenser and the procedure was the same. A reagent blank was found to be constant and gave a value in the results reported of 0.003 absorbance units.

The same procedure as previously described *(16)* was followed for all fishery materials.

PROCEDURE NOTES AND RESULTS

Spectral analysis. Figure 1 shows the absorption spectra obtained with the hydrolysis product of TEP and TBA. The spectra for a sample of oxidized rock-

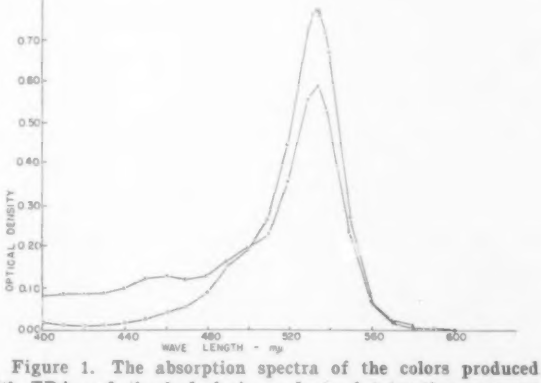

Figure 1. The absorption spectra of the colors produced with TBA and the hydrolysis product of tetraethoxypropane (malonaldehyde) (o), and oxidized rockfish meal (x).

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fish meal (*Sebastodes* sp.) are also plotted for comparative purposes. Both materials show an absorption maximum at 535 mμ.

According to the results obtained TEP hydrolyzes easily under the acid conditions described to yield malonaldehyde which reacts with TBA to produce the typical red color. The intensity of the red color is dependent on the concentration of TEP. Figure 2 shows the effect on concentration of TEP, hydrolysis product, and the intensity of the resultant color. A quantitative relationship is obtained. The maximum sensitivity claimed for this determination is 2×10^{-8} moles in 100 ml., which gives an absorbance of about 0.03. Using the Beckman spectrophotometer, duplicate blanks were reproducible to about 0.003 absorbance units.

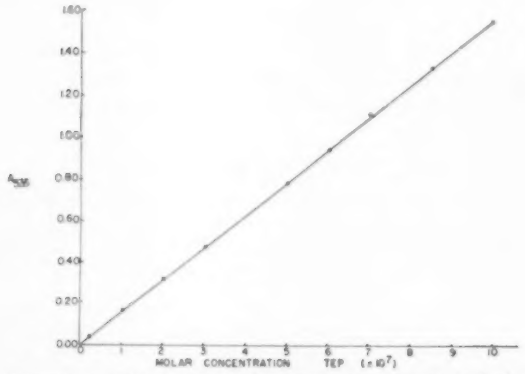

Figure 2. Relationship of absorbance of the hydrolysis product of TEP (malonaldehyde) with TBA vs. concentration of TEP.

The molar extinction coefficient at 535 mμ for the red, TBA reaction product derived from TEP was 1.56×10^5 at a pH of 0.9. The concentration of malonaldehyde can then be calculated from the spectrophotometric data. We propose the use of the term "TBA number" as the milligrams of malonaldehyde per 1000 grams of sample. The TBA number may be obtained by multiplying the $E^{1\%}_{1cm}$ at 535 mμ by a constant. The value of the constant derived from the curve and data presented in this report is 46. A sample of 1,1,3,3-tetramethoxypropane and another sample of TEP from a different source gave the same molar extinction coefficients as reported for the tetraethoxy compound used as a standard.

The results previously presented by Yu and Sinnhuber *(16)* may then be expressed in milligrams of malonaldehyde per 1000 g. of sample, TBA number. It is of interest that in this report canned and frozen fish of good quality gave calculated TBA numbers (milligrams of malonaldehyde per 1000 g. of sample) of less than 3; products of poorer quality gave TBA numbers from 4 to 27. A fish meal sample, freshly prepared, gave a TBA number of 21, and badly oxidized samples approximately 300. Values for fish oils ranged from 14 in fresh salmon oil to 300 in a badly oxidized sample.

Reaction time. A study of the reaction time and color density was made. In the previous paper *(16)*, it was reported that 40 minutes in a boiling water bath was required for fish materials. It was found that the TEP hydrolysis product reacted with the TBA more readily and a maximum was reached in about 20 minutes. The optical density results obtained were as follows: 15 min. 0.386; 20 min. 0.454; 30 min. 0.450; 40 min. 0.458.

Recovery values. Total recovery experiments were made using a known quantity of TEP added to various fishery products. The amount of TEP added was equivalent to an optical density of 0.480. The results are shown in Table 1.

TABLE 1

Total recovery of malonaldehyde

Sample	Initial Optical density	Final Optical density	Total recovery
Tuna, frozen *T. germo*	2.87	3.31	98.6
Rockfish, frozen *Sebastodes*, sp.	0.315	0.745	93.8
Dover sole, frozen *M. pacificus*	0.030	0.483	94.7
Rockfish meal *Sebastodes* sp.	0.414	0.851	95.2
	0.374	0.796	93.2
Herring meal *C. pallasii*	0.458	0.870	92.8
Salmon oil *Onchorhynchus* sp.	0.404	0.841	95.2
Corn oil	0.013	0.482	97.8

Storage, antioxidants and TBA number of frozen tuna scrap. Scrap fish and fish offal are used for fish hatchery food and constitute a large portion of the diet of fur bearing animals, mink and fox. Oxidative rancidity occurs in prolonged freezer storage of these fishery materials. The feeding of these rancid fats has resulted in the condition described as "yellow fat" disease in mink *(8)* and swine *(4)*. A similar condition has been observed by the authors in young chinook and silver salmon fed diets containing high levels of rancid fats. Japanese workers have reported on the toxicity of autoxidized fish oils *(9)* and oxidized unsaturated fatty acids *(6)* in experiments with rats.

Large quantities of tuna scrap are available from the tuna canning operations. This frozen by-product has been tested in mink rations, but the rapid autoxidation that takes place has discouraged the use of this material. The oxidative rancidity that occurs and the effect of 2 antioxidants are shown in Figure 3. Tuna scrap *(T. germo)* was ground in a food grinder, one portion, A, was held as the unheated control. The remainder was heated for 30 minutes at 121° C. in an autoclave.

The processed tuna scrap was then divided into 3 lots; B was kept as the processed control; C received 0.05% N, N'-diphenyl-p-phenylenediamine (DPPD); D was treated with 0.05% Tenox IV.[c] All samples were stored in tightly sealed glass jars at −12° F. for subsequent TBA determinations. DPPD,

[c] Tenox IV is a product of Eastman Chemical Products, Inc., and is composed of 20% butylated hydroxyanisole, 20% butylated hydroxytoluene, 60% vegetable oil.

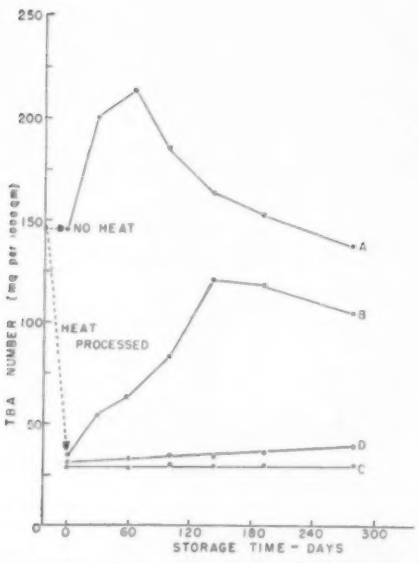

Figure 3. The relation of storage and treatment of frozen tuna scrap to TBA number

A. Unheated control
B. Heated control
C. Heated, 0.05 per cent DPPD
D. Heated, 0.05 per cent Tenox IV

although not now permitted for use in food or animal feed, is included for comparative purposes. Heating the fish caused a rapid drop in the TBA number; whether this is a polymerization reaction or a reaction between malonaldehyde and some portion of the fat or protein has not been ascertained. Apparently, it is not due to volatilization because sealed containers of rancid materials give similar results. A lowering of the peroxide value is a common observation in heat-treated rancid products. Sample A had developed a strong rancid odor in 1 month of storage. Sample B, which had been heat processed, became more rancid somewhat slower and had developed a strong odor in approximately 100 days. Both samples A and B were definitely extremely rancid at the end of the experiment. Samples C and D showed little change in odor or TBA number during the course of the experiment.

SUMMARY

Oxidative rancidity in fat-containing foods leads to the formation of malonaldehyde or derivatives of this compound. The red reaction product formed by the reaction of malonaldehyde and 2-thiobarbituric acid (TBA) is an effective means of measuring the extent of autoxidation. The TBA procedures previously described, although useful in studying the development of oxidative rancidity, are of empirical design. A quantitative, 2-thiobarbituric acid procedure for measurement of malonaldehyde, using the stable compound TEP as a standard, is proposed. Acid hydrolysis of TEP yields malonaldehyde which reacts with 2-thiobarbituric acid, under the conditions described, to afford a quantitative method for the determination of malonaldehyde. The term, TBA number or milligrams of malonaldehyde per 1000 grams of material, is suggested. The reaction time, total recovery, and spectral characteristics of this reaction compound are presented. The method is sensitive to 10^{-8} moles of malonaldehyde in 100 ml. of solution.

The autoxidation that occurs in frozen tuna scrap and the effect of the antioxidants, DPPD and Tenox IV in preventing oxidative rancidity was followed with this procedure.

The present paper, although presenting a quantitative method for malonaldehyde, does not definitely establish that free malonaldehyde exists in rancid fish products. The mechanism of the development of malonaldehyde and the role of this compound in fat oxidation awaits positive identification and isolation of this material from oxidized fat. Research on the isolation of this material and characterization of the TBA-malonaldehyde pigment is in preparation.

Acknowledgment

The authors wish to thank the Union Carbide and Carbon Chemicals Company, New York City, New York, for the 1,1,3,3-tetraethoxypropane which made this work possible. Our thanks are also extended to Kay-Fries Chemicals, Inc. of New York, N. Y. for supplying us with 1,1,3,3-tetramethoxypropane and 1,1,3,3-tetraethoxypropane. We are grateful to Eastman Chemical Products, Inc. of Kingsport, Tenn. for the Tenox IV and the E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. for the diphenyl-p-phenylene-diamine used in this work.

LITERATURE CITED

1. Bernheim, F., Bernheim, M. L. C., and Wilbur, K. M. The reaction between thiobarbituric acid and the oxidation products of certain lipids. *J. Biol. Chem.*, **174**, 257 (1947).
2. Biggs, D. A., and Bryant, L. R. The thiobarbituric acid test for butterfat oxidation. *Can. J. Technol.*, **31**, 138 (1953).
3. Caldwell, E. F., and Grogg, B. Application of the thiobarbituric acid test to cereal and baked products. *Food Technol.*, **9**, 185 (1955).
4. Davis, C. L., and Gorham, J. R. The pathology of experimental and natural cases of "yellow fat" disease in swine. *Am. J. Vet. Research*, **15**, 55 (1954).
5. Jennings, W. G., Dunkley, W. L., and Reiber, H. G. Studies of certain red pigments formed from 2-thiobarbituric acid. *Food Research*, **20**, 13 (1955).
6. Kaneda, T., Saka, H., and Ishii, S. Nutritive value or toxicity of highly unsaturated fatty acids. II. *J. Biochem. Japan*, **42**, 561 (1955).
7. Kohn, H. I., and Liversedge, M. On a new aerobic metabolite whose production by brain is inhibited by apomorphine, ergotamine, epinephrine, and menadione. *J. Pharmacol.*, **82**, 292 (1944).
8. Mason, K. E., and Hartsough, G. R. "Steatitis" or "yellow fat" in mink, and its relation to dietary fats and inadequacy of vitamin E. *J. Am. Vet. Med.*, **114**, 72 (1951).
9. Matsuo, N. Studies on the toxicity of fish oil. II. *J. Biochem. Japan*, **41**, p. 647 (1954).
10. Patton, S., Keeney, M., and Kurtz, G. W. Compounds producing the Kreis color reaction with particular reference to oxidized milk fat. *J. Am. Oil Chemists' Soc.*, **28**, 391 (1951).
11. Patton, S., and Kurtz, G. W. 2-Thiobarbituric acid as a reagent for detecting milk fat oxidation. *J. Dairy Sci.*, **34**, 669 (1951).
12. Schwartz, M. G., and Watts, B. M. Application of the

thiobarbituric acid test as a quantitative measure of deterioration in cooked oysters. *Food Research*, **22**, p. 76 (1957).

13. Sidwell, C. G., Salwin, H., and Mitchell, Jr., J. M. Measurement of oxidation in dried milk products with thiobarbituric acid. *J. Am. Oil Chemists' Soc.*, **32**, 13 (1955).
14. Turner, E. W., Paynter, W. D., Montie, E. J., Bessert, M. W., Struck, G. M., and Olson, F. C. Use of 2-thiobarbituric acid reagent to measure rancidity in frozen pork. *Food Technol.*, **8**, 326 (1954).
15. Wilbur, K. M., Bernheim, F., and Shapiro, O. W. The thiobarbituric acid reagent as a test for the oxidation of unsaturated fatty acids by various agents. *Arch. Biochem.*, **24**, 305 (1949).
16. Yu, T. C., and Sinnhuber, R. O. 2-Thiobarbituric acid method for the measurement of rancidity in fishery products. *Food Technol.*, **11**, 104 (1957).

Informational Bias in Flavor Preference Testing[a]

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Considerable effort is given in the conduct of many laboratory flavor tests to the elimination of biasing influences from suggestion or past experience. This is done through careful coding systems, color-equalizing lighting, isolation of tasters from each other and from food preparation areas, the restriction of conversation and discussion, and by other means. Uncontrollable influences may include such factors as the knowledge or experience which a taster brings with him to the tasting situation.

Psychological aspects of flavor include attitudes, experience, memory, expectations, suggestions, motivations, or other factors of learned behavior. Josephson *(4)* maintains that "the average human being is equipped with an extremely sensitive taste mechanism, with which to evaluate flavor, as well as a taste memory to which he can refer in establishing his acceptance of a food." Crocker, Sjöström and Tallman *(1)* consider that a taster's knowledge, or guess, as to the source or maker of a product may cause assumptions to be made concerning flavor and quality which will influence his opinion. The setting, the questions, the personality and attitude of the investigator may, as they see it, all recall past experiences and influence the consumer's interpretation of his immediate flavor experience. Harper *(3)* suggests that flavor judgments are likely to be "easier and more correct if the person making them knows the general type of variation which he is about to meet."

Foster, Pratt and Schwartz *(2)*, in ascertaining the effect of voiced responses of taste panel members on other panel members, observed that the responses of members of a round-table group can be influenced by the voiced report of the first observer. This biasing influence was not apparent with every product tested, but it was shown that qualitative flavor differences and preferences can be created where none exist, that is, in samples which are identical. Round-table testing methods may result, they state, in data of only precarious reliability, because of the potential influence of the voiced judgment of a single member on the entire group. They concede, however, that a round-table environment may most closely approach the home consumer situation.

Flavor preference testing presents always the danger that the preference findings have been influenced by knowledge or suggestion which have crept into the testing situation. To prevent the possibility of such bias is a frequent concern of the flavor test operator. Understanding the influence of specific information should promote confidence in the conduct of flavor testing procedures.

This work was initiated to ascertain, in the case of one product, in what way specific information possessed by the tasters concerning the product might alter the results obtained by the flavor preference panel.

EXPERIMENTAL PROCEDURE

Seven separate flavor tests were conducted using 3 different panels of men and women college students. The tasters on the panels were not screened or pre-selected and participated solely on the basis of their interest in responding to an open call for tasters. They were paid a small amount for their time. Each test of the series consisted of serving simultaneously on a tray to each taster 3 portions of identical commercially packed tomato juice, accompanied by specific printed information. The juice was served in small paper cups, identified by appropriate codes. One of the 3 samples was identified as reference by R, marked on the cup. The other 2 samples were identified by four-digit numbers, obtained from a random number table. Two ounces of tomato juice were contained in the reference cup, whereas the coded cups each contained 1½ ounces of juice.

Tasters were seated in individual tasting booths lighted

[a] Technical Paper No. 1028, Oregon Agricultural Experiment Station.

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uniformly with white incandescent light and equipped with individual porcelain sinks, hot and cold water supply, pencils, and service counter. Paper rinsing cups were provided, to be used at the tasters' own discretion.

Two printed reference-type ballots were given each taster with each tray of samples. One of the ballots was specifically identified by number with one of the coded cups on the tray; the other ballot was identified with the other coded cup. These ballots gave uniform instructions concerning the procedure of tasting and the use of scoring columns, Figure 1,

EFFECT OF INFORMATION

Flavor Test Ballot

Date:_____ Product:_____ Name:_____

INSTRUCTIONS:

The cup labeled "R" contains a reference sample. Compare the flavor of sample_____directly with the flavor of the reference sample.

(a) Taste the reference and the sample as many times as necessary.

(b) Check the space on this ballot which indicates your judgment concerning this sample:

Much better flavor than reference	(Specific Informational statement is written here concerning sample numbered above)
Moderately better flavor	
Slightly better flavor	
Neither better nor poorer flavor	
Slightly poorer flavor	
Moderately poorer flavor	
Much poorer flavor than reference	

Comments:

When finished, please open sliding door, push cups through. Place ballot in ballot box. Thank you.

BE SURE YOUR NAME IS WRITTEN ON THIS BALLOT

Figure 1. Flavor test ballot and instructions for use.

but each contained in addition, in a prominent position adjacent to the scoring column, a specific statement of information related to the cup with which it was identified. The order in which the 2 ballots were presented to each taster was randomized.

Statements for each pair of coded samples presented on a single tray were contrasting in nature. It was intended that they provide the taster with differing information about some aspect of raw product quality or processing treatment in connection with the two coded, identical samples being flavor tested at one time. The statements used are given in Figure 2. The first 3 tests were conducted at a single sitting with a panel of 132 college students. Tests 4 and 5 were conducted at a single sitting with a panel of 49 college students. Tests 6 and 7 were conducted at a single sitting with a taste panel of 39 college students. The order in which the test trays, containing samples and paired ballots, were presented in each instance was randomized from taster to taster. No information was given to the tasters pertaining to the nature of the tests other than appeared on the printed ballots. No verbal instructions were delivered by the serving attendants. In all cases the paired juice samples were identical juice. The informational statements were fictitious, although this was not known to the tasters.

ANALYSES AND RESULTS

Judgments obtained from the tasters were transposed to numerical scores on a 7-point scale in which 4 represented "neither better nor poorer flavor" in the center of the scale. "Better flavor" ascended and

Test 1:
- (a) Juice prepared from CAREFULLY SELECTED, SUN-RIPENED, FANCY GRADE tomatoes.
- (b) Juice prepared from UNSORTED, RAIN-DAMAGED, SUBSTANDARD tomatoes.

Test 2:
- (a) CHEMICALLY TREATED tomato juice.
- (b) Juice which has NOT BEEN TREATED with chemicals.

Test 3:
- (a) Juice which HAS BEEN EXPOSED TO RAYS for the purpose of sterilization.
- (b) Juice which has NOT BEEN EXPOSED TO RAYS for sterilization.

Test 4:
- (a) Juice which has had MONOSODIUM GLUTAMATE added to it.
- (b) Juice which **has not** had Monosodium Glutamate added to it.

Test 5:
- (a) Juice which has had SALT added to it.
- (b) Juice which **has not** had Salt added to it.

Test 6:
- (a) Juice which has had SUGAR added to it.
- (b) Juice which **has not** had Sugar added to it.

Test 7:
- (a) Juice which has had LEMON JUICE added to it.
- (b) Juice which **has not** had Lemon Juice added to it.

Figure 2. Contrasting statements of information presented to tasters in flavor preference tests of commercially packed tomato juice.

"poorer flavor" descended on the scale. Scores obtained for the coded identical samples were then tabulated and analyzed for each test by analysis of variance.

A summary of the findings of the analyses of variance for the 7 tests is given in Table 1. Under the conditions of these tests, it is expected that the true scores for the coded samples in each case would not significantly differ from 4. The mean scores obtained,

TABLE 1

Effect of information on flavor panel preference

Summary of analyses of variance for individual tests

	Source of variation	F value
Test 1:	Raw Quality Information	28.93**
	Tasters	1.37*
Test 2:	Chemical Information	0.00
	Tasters	1.32*
Test 3:	Rays Information	3.78
	Tasters	1.45*
Test 4:	MSG Information	0.28
	Tasters	1.42
Test 5:	Salt Information	25.36**
	Tasters	1.35
Test 6:	Suar Information	10.71**
	Tasters	1.69
Test 7:	Lemon Juice Information	5.26*
	Tasters	1.07

*Significant at 5%.
**Significant at 1%.

TABLE 2

Effect of information on flavor panel preference

Mean scores of duplicates to the reference

Type of information	Mean score	Number of tasters
High quality raw product	4.37	132
Low quality raw product	3.71**	132
Chemical treatment	4.02	132
No chemical treatment	4.02	132
Exposed to rays	4.16	49
Not exposed to rays	3.90	49
MSG added	4.27	49
MSG not added	4.14	49
Salt added	4.69	39
Salt not added	3.71**	39
Sugar added	4.41	39
Sugar not added	3.72**	39
Lemon juice added	4.36	132
Lemon juice not added	3.82*	132

*Significantly different at 5%.
**Significantly different at 1%.

Table 2, reveal that with respect to the product tasted:

(a) Information concerning high quality raw product clearly raised the panel preference, whereas information of low quality raw product lowered the panel preference.

(b) Information with respect to treatment by unspecified chemicals, exposure to unspecified sterilizing rays, and addition of monosodium glutamate did not alter the panel findings.

(c) Information that salt was added raised the panel preference, whereas the statement that salt had not been added lowered the preference.

(d) Information that sugar was added raised the preference, and the statement that sugar had not been added lowered the preference.

(e) Information that lemon juice was added raised the preference, whereas the statement that lemon juice had not been added lowered the panel preference.

Analyses indicate that the scores of individual tasters significantly differed with respect to the tests involving information of treatment by chemicals, exposure to rays, and quality of raw product, but that the individual tasters' scores did not significantly differ in the tests involving information regarding the addition of lemon juice, sugar, salt, and monosodium glutamate. This would signify agreement among the tasters with respect to either the effect or the lack of effect of certain parts of the information; namely, information on the addition of lemon juice, sugar, salt, and monosodium glutamate to the tomato juice. In the cases of information concerning chemicals, rays, and raw product quality, the possibility is suggested that some of the tasters may have been influenced while others were not. Although there was lack of agreement in preference among some tasters in the case of the raw product quality information, the flavor panel preference result was nevertheless clearly altered by this information.

SUMMARY AND CONCLUSIONS

Results of these flavor tests indicate that some types of information affect the panel preference for tomato juice while others do not. The preference result by the taste panel was altered by information concerning the quality of the raw product, the presence or absence of salt, of sugar, or of lemon juice in the tomato juice. It was unaffected by information concerning the presence of monosodium glutamate, treatment with unspecified chemicals, or treatment by rays. This could imply that only information which has meaning within the range of experience of the tasters may be expected to influence the preference results.

It might reasonably be considered that the college students composing these flavor panels had little or no experience with chemical treatments, monosodium glutamate, or sterilizing rays in food products, and thus these statements had little or no meaning to them, whereas the use of salt, sugar, or lemon juice in tomato juice or similar products is probably a relatively common experience to all. It is likely also that tomatoes as a raw product in varying degrees of perfection or imperfection were well known to these tasters.

These possibilities suggest the conclusion that if the information conveyed to tasters has meaning within terms of their experience, it may influence their preference, but if the information does not have meaning it may not affect the preference judgment. It leads to the consideration that tasters may taste what they expect to taste. It is clear from these flavor tests that information conveyed to, or possessed by, tasters has the potential of altering preference findings of the flavor panel.

LITERATURE CITED

1. Crocker, E. C., Sjöström, L. B., and Tallman, G. B. Measurement of food acceptance. *Ind. Eng. Chem.*, 40, 2254–2257 (1948).
2. Foster, D., Pratt, C., and Schwartz, N. Variation in flavor judgments in a group situation. *Food Research*, 20, 539–544 (1955).
3. Harper, R. Fundamental problems in the subjective appraisal of foodstuffs. *Applied Statistics*, 4 (3), 145–161 (1955).
Josephson, D. V. Flavor origins—review of chemical mechanisms affecting flavor acceptability of dairy products. *J. Agr. Food Chem.*, 2 (23), 1182–1184 (1954).

A New Type of Bread

Wheat-and-Rice Bread[a]

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When the work, herein reported, was planned, the objective was to bring about a higher consumption of rice than of wheat in Venezuelan diet. Rice is a cereal that may be grown easily in Venezuela, whereas wheat may not. Further details on this aspect of the subject may be found in a previous study *(11)*.

The present study approaches the problem from the standpoint of nutrition. Though a theoretical analysis of the amino-acids of the two components, wheat and rice (Table 1), appeared nutritionally favorable, direct answers to the following questions were needed: is it possible to make a wheat-and-rice bread whose protein value would be superior to that of the average wheat bread? In what proportion should the two kinds of flour be mixed? Will the wheat-and-rice bread have the same characteristics as the bread commonly used with respect to its manufacture, appearance, taste and storage ability? Would the public be willing to accept wheat-and-rice bread if essential differences exist? Would the price of this new bread be higher, equal to, or less than that of wheat bread?

Those questions show clearly the scope of the problem to be solved. References *4, 6, 7, 9, 12, 13* formed the basis for providing the answers. The questions represent, of course, the criteria on which a sound evaluation could be made.

PROCEDURES

After several preliminary testing experiments had been tried, using different quantities of rice varying from 10%, 20%, 30%, 40%, up to 50%, 30% was decided upon as the most convenient and usable. While this proportion of 30% rice: 70% wheat represents an outlet for rice production, and thus contributes to the economic aspect, on the other hand a new brand of starch has to be dealt with and a different technique of bread-making has to be devised. The success of the formula (to be presented later), depends upon two fundamental changes, working simultaneously, namely; an increase in the quantity of yeast used and an increase in the fermentation time.

Details. The process used, although based upon our own experience, might be further improved by modification. Under our procedure wheat and rice flour are mixed in the proportion of 7:3. The quantity of yeast is increased by 25% over that of the bread commonly used in Venezuela.

Formula:

Mixed flour	1 kg.
Water	½ liter
Yeast	25 g.
Salt	20 g.
Fat	30 g.

One may choose to add: yeast food, milk, raisins, prune juice, emulsifying substances, eggs etc. or any ingredient that might contribute to the taste, aroma, texture or nutritional characteristics.

Preparation. The two kinds of flour, wheat and rice, are first mixed, and then water, yeast, fat and salt are added. This mixture is left for an hour at the surrounding temperature (25° C.), after which the dough is worked up twice every 15 minutes. (Fase de volteo).[c] Finally, baking is performed in varnished moulds at a temperature of 220° C. for 45 minutes.

In our preparation procedure, the so-called "direct process" (straight dough process) is used. The indirect method (sponge and dough process) can also be used. This consists of fermenting the dough with a portion of the yeast for at least 4 hours. From this method one obtains something the bakers call "pie". Then the remaining flour is added, the dough is mixed once more and allowed to stand for two hours. Then one can proceed exactly as in the direct method. The advantage is that less yeast is used. The disadvantage is that more time is required.

DISCUSSION

Characteristics. This new kind of bread has many excellent characteristics and advantages. For one thing, it corresponds exactly with the requirements of the Pan American Law Project for Food (Dr. Carlos A. Grau, Director). It also meets the Food and Drink regulations of Venezuela. It does not contain more than 40% water and there is less than 3% ash. It is porous, has an agreeable aroma, has good baking performance, and is soft and elastic.

Wheat-and-rice bread cannot be distinguished from common bread by its taste. It keeps perfectly for 4 days, whereas wheat bread becomes completely hard after two days. Wheat-and-rice bread is acceptable even after four days.

Figure 1 shows the different structures of the two breads.

[a] The author wishes to thank the following persons: Dr. A. Castillo Plaza, chief of the Nutrition Department of the INN who advised and encouraged us; and Messrs. Fleischmann-Ling and Acuña, the former of the Pasteleria Vienesa, the latter of the Panaderia Ferrenquin, for their invaluable help in examining the samples.

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TABLE 1

Amino-acids of rice, polished rice and wheat flour calculated on the basis of 16.0 g. of N

Amino-acids	Rice *(1)*	Polished rice *(3)*	Wheat flour *(1)*
Arginine	7.2	....	3.9
Histidine	1.7	1.6	2.2
Lysine	3.2	3.8	1.9
Tyrosine	5.7	....	3.8
Tryptophan	1.3	1.2	0.8
Phenylalanine	5.0	4.6	5.5
Cystine	1.3	....	1.9
Methionine	3.0	2.2	2.0
Threonine	3.8	....	2.7
Serine	....	....	4.3
Leucine	8.2	8.0	7.0
Iso-Leucine	5.2	6.0	4.2
Valine	6.2	6.2	4.1

[c] When making wheat bread, a single treatment—the so-called "Fase de volteo"—would be more than enough to obtain a good kind of bread. "Fase de volteo" a baker's technical term means that the dough is worked up homogeneously so as to become ball-shaped.

Figure 1. On the left 350 g. wheat bread, made up to be compared under the same conditions with wheat-and-rice bread on the right, weight 360 g. The porosity of the two kinds of bread can be observed.

A thorough-going survey of the consumer response to this new bread, including its reception by the different social groups, should be made, and it is recommended that the National Institute for Nutrition (Venezuela) through the Department of Public Relations set up such a survey. Sound conclusions could be established by subjecting the results to statistical treatment.

Economic analysis. All Venezuelans, without distinction, consume rice grain as a food cereal. Wheat is principally used in the form of flour to make bread. As to the value of Venezuelan production of both cereals the difference is enormous, as Table 2 shows.

TABLE 2

Rice and wheat production (Venezuela) in tons from 1949 to 1955

Products	1948	1949	1950	1951	1952	1953	1954	1955
Unpeeled rice	41,650	35,874	38,645	40,000	49,336	57,931	102,343	60,000
Wheat	5,390	4,572	4,607	4,190	6,298	3,100	2,012	1,837

Wheat flour is imported, whether in the form of flour or in the form of grain to be milled into flour. In 1955, Venezuela imported 178,682 tons of wheat flour *(3)*, at considerable cost. Moreover, the money might better have been paid to Venezuelan growers rather than to those of foreign countries.

As to the price, wheat flour is bought wholesale at Bs. (Bolivar) 0.78 a kg. and rice in grains at Bs. 1.05 a kg. *(3)*.

In 1955, wheat flour in the amount of 178,682 tons *(8)* was imported. Thirty per cent of this quantity would be 53,604.6 tons. Thus, the sum of Bs. 41,811,588 goes abroad annually.

It would be beyond the limits of this brief analysis and beyond the investigator's prerogatives to dictate the rules to be followed to improve the situation. That, of course, is the business of economists. However, it may not be presumptuous to suggest that the Government might, by means of a regulatory statute, oblige bakeries to utilize a certain quantity of rice flour. The benefit that would accrue to the economy would appear to be a a very considerable one.

Nutritional aspects. Since lysine, methionine, and threonine are limiting factors in wheat flour protein, and since rice flour is high in these amino acids, experiments have been made concerning the value of the protein supply in wheat-and-rice bread, wheat bread, the components in the form of mixed flour, and the individual flours. Experiments were carried out with rats (Sprague Dawley [4]), 4 to 5 weeks old at the start of the experiment and having a weight of 50–55 g. The rats were fed *ad libitum* on food and water. To each of the diets minerals and vitamins were added as described previously *(10)*. The quantity of food taken in was controlled and weighed individually. Results are given in Table 3.

SUMMARY

A wheat-and-rice bread is offered as a substitute for common wheat bread, without diminishing the organoleptic qualities or the nutritional values expected in good wholesome bread. The figure of 30% rice flour replacing wheat flour is experimentally well founded, the consequence of agro-economical and nutrition considerations.

The protein efficiency of the wheat-and-rice bread compared with wheat bread was increased by 9.1% and the growth of rats by 7.7%. Although wheat bread contains 12.73% proteins, whereas the wheat-and-rice bread contains only 11.78% protein, it appears that the amino acid pattern of the latter accounts for the better efficiency.

The new wheat-and-rice bread can be made in any bakery and only requires a quantity of 25% more yeast than is usual. Fermentation time is longer when applying the straight dough method. The wheat-and-rice bread could have a favorable influence on the Venezuelan economy, since rice is indigenously produced whereas wheat is not.

[4] These animals were fed previously on a ration completely composed of commercial food; this ration fulfilled all the normal nutrition needs.

TABLE 3

Protein values of wheat-and-rice bread and its components

Diet	Protein[1]	Number of animals (half males, half females)	Duration of experiments (weeks)	Gain of weight	Increase	Total food consumed	Protein consumed	P. E.[2]	Increase
				grams		*grams*	*grams*		
Rice flour	9.13	8	6	50.3		383.3	34.5	1.45 ± 0.05	
Wheat flour	13.95	8	6	63.1		481.9	67.2	0.94 ± 0.02	
Mixture of wheat and rice flour 7: 3	11.75	8	6	72.0		483.1	56.8	1.27 ± 0.03	
Wheat bread	12.73	8	6	37.5		339.4	43.2	0.87 ± 0.03	
Wheat-and-rice bread	11.78	14	6	40.4	7.7	362.5	42.9	0.95 ± 0.02	9.1

[1] To calculate the contents of N in proteins the following factors were used: 5.95 for rice flour and 5.7 for wheat flour and wheat bread (FAO Elementos nutritivos Productores de energía en los alimentos y cálculo de los valores energéticos en calorías. 1947, pág. 8). The factor 5.78 used for wheat-and-rice bread is a modality that was introduced by us.

[2] Protein efficiency or increase per gram of consumed protein; average error in measure according to the formula: $\sqrt{\frac{\Sigma d_2}{n(n-1)}}$

LITERATURE CITED

1. Block, R. J., and Bolling, D. *The Amino Acid Composition of Proteins and Foods.* 2nd ed. 1951. Charles C Thomas, Publishers. 1951.
2. Boletín de Estadistica del Ministerio de Fomento de Venezuela. Noviembre-diciembre. 1955. Page 126.
3. Boletín de Estadistica del Ministerio de Fomento de Venezuela. Junio. 1956. Pages 52–54.
4. Brastow, Parks V., Hewston, E. M., Marshall, M. W., and Bruinooge, A. M. Developing breads of higher nutritive value. *J. Am. Diet. Assoc.*, **30**, 245–250 (1954).
5. Commonwealth Bureau of Animal Nutrition. Rowett Institute, Bucksburn, Aberdeenshire, Scotland: *Tables of the Amino Acids in Foods and Feedingstuffs.* Compiled by D. Harvey. Page 30 (1956).
6. Horder, Lord, Dodds, Sir Charles, and Moran, T. *Bread, the Chemistry and Nutrition of Flour and Bread.* 1954. Published by Constable and Company Ltd.
7. Kent-Jones, D. W., and Amos, A. J. *Química Moderna de los Cereales.* 1956. Ediciones Aguilar, Madrid.
8. Memoria del Banco Central de Venezuela. 1955. Page 62.
9. Moreno Calvo, J. Aspectos Bioquimicos del Pan y de la Harina. *Rev. Anales de Bromatologia* (España), **6**, 337–354 (1954).
10. Mosqueda-Suárez, A. Estudio de los Métodos "Recolección" y "Oxido Crómico" en la rata. Sus aplicaciones para conocer la digestibilidad de la Arepa. *Arch. Venez. Nutr.*, **6**, 74 (1955).
11. Mosqueda-Suárez, A. Consideraciones sobre el Uso del Trigo y el Maíz en Venezuela. *Rev. Temas Económicos.*, **6** (5) (agosto-septiembre), 58–64 (1956).
12. United States Department of Agriculture. Bread, facts for consumer education. 1955. Page 5.
13. Wihlfahrt, J. E. *A Treatise on Baking.* 1950. Publishing by the Fleischmann Division, Standard Brands Incorporated.

Factors Affecting Quality of Prepackaged Meat[a]

II. Color Studies. D. Effects of Nitrogen and Carbon Dioxide under Different Pressures upon Color of Product[b]

(Manuscript received March 20, 1956)

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That high vacuum hastens the return of redness in fresh meat has been shown previously.[c] In additional work, an attempt was made to exclude air completely by flushing the air out of desiccators with carbon dioxide gas or with nitrogen gas before evacuating.

EXPERIMENTAL

Ground fresh ham samples were prepared as usual and placed in 3 desiccators; 12 samples in each. The desiccator to be flushed with CO_2 was disconnected from the vacuum pump after drawing a vacuum of about 72 cm. and connection was made to a CO_2 cylinder. The gas was let into the desiccator until atmospheric pressure was reached. Vacuum was drawn again and the CO_2 flushing repeated. Finally, vacuum was drawn and the desiccator stored. The same flushing procedure was followed for the desiccator in which N_2 was the test gas. The control desiccator was not flushed with gas but was merely evacuated, sealed, and stored. The pressure in each desiccator was determined at each removal, as it was at the time of storage, and the average pressure for the desiccator obtained for the entire examination period. After two of the samples were removed for color determinations, each desiccator was put through the same gas treatment as employed originally and restored until the next removal.

Since the color of unpackaged samples seemed to be improved by flushing the desiccator with gas prior to final evacuation, the effect on color of packaged samples stored in desiccators which had been flushed with CO_2 was determined (Run U). Twenty-four lean ground lamb samples were packaged in cellophane-pliofilm laminate film under 27 inches of vacuum. Packaged samples were equally divided between 2 desiccators. Twelve unpackaged samples were placed in each of two other desiccators. One of the desiccators containing packaged samples and one containing unpackaged samples were flushed with CO_2 before final evacuation, while the other 2 desiccators were merely evacuated. The average pressure in

[a] A report of work conducted by contract with the Bureau of Animal Industry, U. S. Department of Agriculture, with funds provided under the Research and Marketing Act.

[b] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Departments of Food Technology and Animal Husbandry, New Brunswick, N. J.

[c] See Section IIC, *Food Technol.*, 11, 625 (1957).

the 4 desiccators was 1.3 to 5.1 cm. during the 7 days of the experiment. Since the packaged samples[d] had been sealed in the film under 27 inches of vacuum and the vacuum in the desiccators was higher (ca. 29 inches), the packages bulged when vacuum was drawn. It appeared that none of the packages was broken, as evidenced by their reversible bulging and shrinking as vacuum in the desiccators was drawn and released at each removal. The desiccators were stored at 40° F. (4.4° C.).

Samples used in Runs S and U were from animals that were raised and slaughtered by the Department of Animal Husbandry, Rutgers University, and were prepared as described in Section IA of this series. Samples used in Runs 1, 2, 5, and 6 were from meat purchased in the retail market and, without holding, prepared in a similar manner to those for Runs S and U.

RESULTS

Inert gas (Runs S and U). Figure 1 shows the redness changes of the top surfaces of ground fresh lean ham samples stored at 40° F. in desiccators that were (a) not flushed, (b) flushed with carbon dioxide gas, or (c) flushed with nitrogen gas before drawing the final vacuum in Run S. Gases used for flushing were obtained from commercial cylinders of carbon dioxide and nitrogen, with a purity of 99.5% and 99.7%, respectively. The vacuum in each desiccator was determined immediately before each removal (while the gas was at 40° F.) with the aid of the mercury manometer. It was found that none of the 3 desiccators was lower than 4.6 cm. or higher than 7.0 cm. of pressure at any removal with the exception of the removal at 5 days. At this examination, the desiccator flushed with CO_2 was found to have 69.7 cm. of pressure indicating that, due to faulty sealing, leakage occurred between the 3rd and 5th days. The mean redness value obtained from the samples stored in the desiccator flushed with CO_2 shows the effect of this loss of vacuum on the color change of the meat. Between 1 and 3 days, the redness began to return in these samples and was lost with the vacuum at 5 days. High vacuum was obtained in all desiccators thereafter, and the samples flushed with CO_2 increased in redness by 9 days to a higher value than at 0 days.

Figure 2 shows the redness changes of the top surfaces of packaged and unpackaged samples of ground lean lamb flushed with CO_2 or not flushed before storage under vacuum in Run U.

[d] The following legend of codes representing the various package types used in this investigation is repeated herewith for the convenience of the reader.

Code Number	*Packaging Material*
2	Can
3	Unpackaged
4a	Vinylidene copolymer (Cry-O-Vac)
6	MSAT86 cellophane, coated both sides
6a	MSAT80 cellophane, coated side inside
6d (1)	MSAT80 cellophane, coated side outside
6w (1)	MSAT80 cellophane, coated side outside (wrapped)
8 (2)	Cellulose acetate P-912
10 (1)	Polyethylene
15	Cellophane-pliofilm laminate, pliofilm inside
16	Cellophane-polyethylene laminate, polyethylene inside
17	Cellulose acetate-pliofilm laminate, pliofilm inside
20	Trithene (wrapped)

(1) "Hand" made in the laboratory; (2) "hand" made by Celanese Corporation; all other film packages except No. 20 were "factory" made by Standard Packaging Corporation.

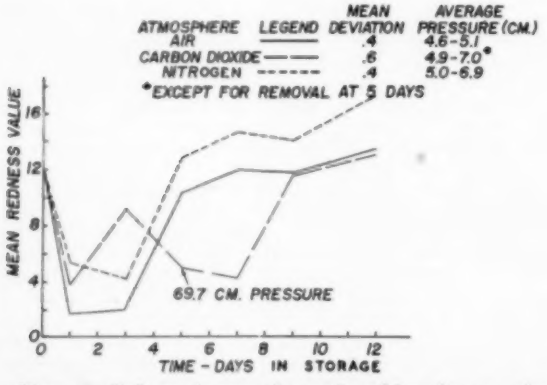

Figure 1. Redness changes of unpackaged ham lean samples stored in low pressures of air, carbon dioxide, and nitrogen. Run S. (Top of samples). (Two replicates).

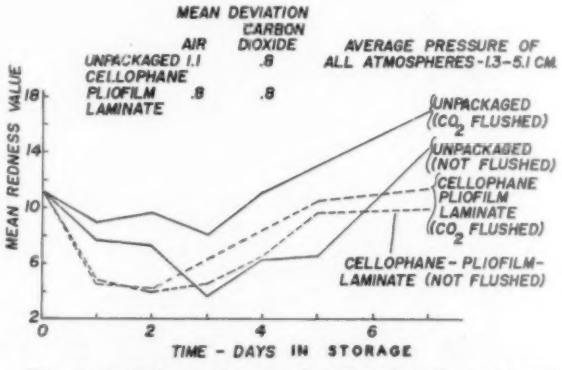

Figure 2. Redness changes of packaged and unpackaged ground lamb lean samples stored in low pressures of air and carbon dioxide. Run U. (Top of samples). (Two replicates).

In another experiment (not shown), samples were stored in desiccators at atmospheric pressure under air, CO_2 or N_2. The samples stored in air decreased in redness for one day only. In 7 days the samples stored in air had regained some, but not all, of their original redness; then they decreased in redness during the remainder of the storage period of 11 days. Samples stored in CO_2 and N_2, after losing redness rapidly in one day, remained fairly constant until 7 days, after which samples stored in N_2 made a partial return in redness, while samples stored in CO_2 increased only slightly in redness.

Mixtures of air and carbon dioxide (Runs 1 and 2). The effect of CO_2 partial pressures above those normally found in the atmosphere on the color changes of fresh beef and cured ham was determined in a short term (Run 1) and a long term (Run 2) experiment. Total initial pressure was approximately one atmosphere, made up of a specified partial pressure of CO_2 and partial pressures of other gases in the proportions in which they are present in air. The partial pressures of CO_2, O_2, and N_2 found in the desiccators at the 3-day removal are plotted in Figure 3 against the mean daily decrease in redness ("k" value)[e] of the top surfaces of ground beef samples for the 3 days of storage. These pressures are also shown in Table 1 for Lots A and B[f] of Run 1. That the calculated initial pressures were almost always higher than the removal pressures was attributed to the fact that the CO_2 used to return the desiccators to atmospheric pressure was always warmer than the storage temperature of from 44° F. to 48° F. As the quantity of CO_2 added was increased, the difference in partial pressure initially and after 3 days of storage became greater.

Figure 3 shows the relationship between "k" for ground

[e] Definition of "k" value: the mean daily decrease in redness of samples during the first 3 days of storage.

[f] Lots A and B each consisted of 5 desiccators. The distinction between the 2 lots was in dates of the storage periods.

TABLE 1

Calculated initial pressures and pressures at removal (3 days) of CO_2, O_2, and N_2 within the desiccators containing meat samples in Run 1

Lot	Desiccator	Calculated initial pressures (cm.) CO_2	O_2	N_2	Pressures at removal (cm.) CO_2	O_2	N_2
A	1	.4	15.7	59.7	.5	15.2	58.2
A	2	11.5	13.4	50.8	9.7	12.7	49.2
A	3	26.7	10.2	38.8	22.9	9.4	36.7
A	4	46.5	6.1	23.1	40.4	5.6	22.0
A	5	65.1	2.2	8.4	57.0	2.3	10.0
B	1	6.8	14.4	54.8	5.7	13.8	53.5
B	2	22.9	11.0	42.1	20.2	10.6	41.4
B	3	36.5	8.2	31.3	32.2	7.3	30.7
B	4	55.8	4.2	16.0	49.2	4.0	17.0
B	5	71.9	0.9	3.2	64.4	0.9	3.8

beef and the partial pressures of CO_2, O_2, and N_2.

Figure 4 shows the "k" values of the top surfaces of ground cured ham samples stored under various initial CO_2 partial pressures.

Figure 5 shows the effect of 3 different initial pressures of CO_2 on the redness changes of the top surfaces of ground beef and ground cured ham stored for 14 days at 41° F. to 44° F. in Run 2.

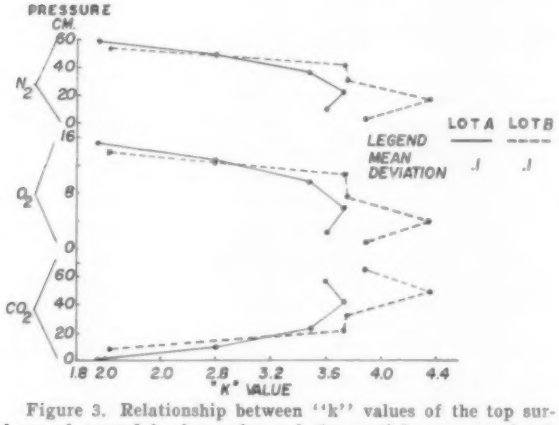

Figure 3. Relationship between "k" values of the top surfaces of ground beef samples and the partial pressures (cm.) of carbon dioxide, oxygen, and nitrogen at removal. Run 1. ("k" Value = Mean daily decrease in redness for the first 3 days of storage). (Four replicates).

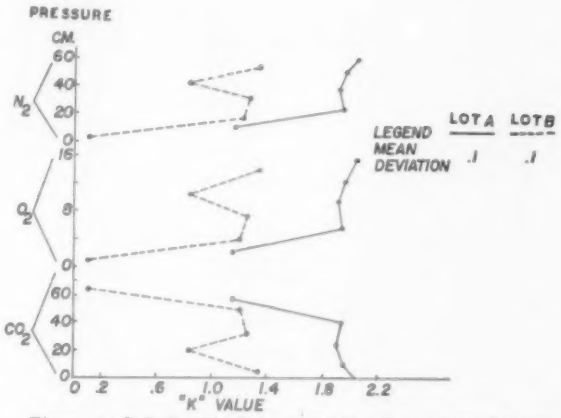

Figure 4. Relationship between "k" values of the top surfaces of ground cured ham samples and the partial pressures (cm.) of carbon dioxide, oxygen, and nitrogen at removal. Run 1. ("k" Value = Mean daily decrease in redness for the first 3 days of storage). (Four replicates).

Table 2 shows the pressures, percentages by volume of carbon dioxide, oxygen, and nitrogen, and partial pressures of carbon dioxide, oxygen and nitrogen calculated from the percentages within each desiccator sealed at atmospheric pressure in which the initial partial pressures of carbon dioxide were 0.2 cm., 27.0 cm., and 72.0 cm.

Mixtures of air and nitrogen (Runs 5 and 6). Table 3 shows the calculated partial pressures of CO_2, O_2 and N_2 in the desiccators at 0 days and the partial pressures of these gases at the 3-day removal in Lots A and B of Run 5. Although the same procedure used in Run 2 for CO_2 was used in adding the N_2 to the desiccators, apparently the gas in the desiccators did not reach the storage temperature of 41° to 45° F., since the partial pressures of O_2 and N_2 were less at 3 days than at 0 days. The increase in CO_2 pressure was insufficient to compensate for this less.

Figure 6 shows the "k" values obtained for the top surfaces of ground beef samples plotted against the partial pressures of CO_2, O_2, and N_2 in the atmospheres surrounding the meat at time of removal. The N_2 and O_2 curves are similar in shape, but reversed in respect to each other. The CO_2 curve is not similar in shape to the other curves. The shape of the CO_2 curve depended on the amount of this gas produced in the desiccators during the 3-day period. With variations in oxygen pressures above normal, as the oxygen pressure was increased, CO_2 was produced more rapidly.

TABLE 2

Pressure, percentage carbon dioxide, oxygen, and nitrogen (vol.), and partial pressure of carbon dioxide, oxygen, and nitrogen within each desiccator sealed at atmospheric pressure in which the initial partial pressures of carbon dioxide were .2 cm., 27.0 cm., and 72.0 cm. Run 2. (Ground beef and ground cured ham)

Initial carbon dioxide pressure (cm.)	Days in storage	Desiccator pressure (cm.)	% Carbon dioxide	% Oxygen	% Nitrogen	Partial pressure carbon dioxide (cm.)	Partial pressure oxygen (cm.)	Partial pressure nitrogen (cm.)
.2	0	75.7	.2	20.9	78.9	.2	15.8	59.7
	2	74.4	.6	20.6	78.8	.4	15.4	58.6
	4	73.8	1.4	19.5	79.2	1.0	14.4	58.4
	8	74.2	9.3	10.8	80.0	6.9	8.0	59.3
	14	73.8	18.0	1.0	81.0	13.3	.8	59.8
27.0	0	75.7	35.7	13.5	50.7	27.0	10.2	38.4
	2	72.4	34.1	13.5	52.4	24.7	9.8	37.9
	4	72.5	34.5	13.1	52.4	25.0	9.5	38.0
	8	71.9	34.3	13.1	52.7	24.6	9.4	37.9
	14	74.8	34.5	12.1	53.4	25.8	9.1	39.9
72.0	0	75.7	95.1	1.0	3.9	72.0	.8	2.9
	2	71.7	94.5	1.1	4.4	67.8	.8	3.1
	4	69.5	94.2	1.0	4.9	65.5	.7	3.4
	8	72.8	90.4	1.6	8.0	65.8	1.2	5.9
	14	73.6	91.3	1.1	7.6	67.2	.8	5.6

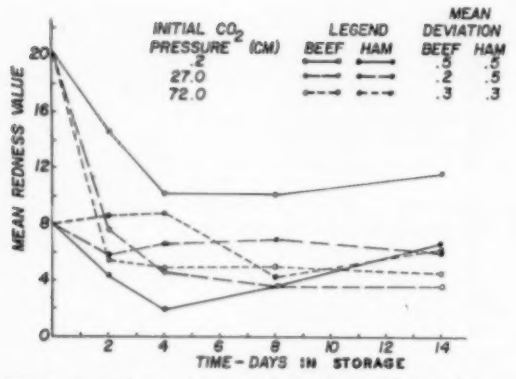

Figure 5. Redness changes of the top surfaces of ground beef and ground cured ham samples stored at atmospheric pressure in atmospheres containing initially .2 cm., 27.0 cm., and 72.0 cm. partial pressure of carbon dioxide. Run 2. (Four replicates).

Figure 7 shows the "k" values obtained for the top surfaces of ground cured ham under the same conditions. No consistent pattern of change in redness was found when the initial N_2 partial pressures were varied.

Figure 8 shows the effect of 3 different initial pressures of N_2 at or above those normally found in the atmosphere on the redness changes of the top surfaces of ground beef and ground cured ham samples stored for 14 days at 43° F. to 46° F. in Run 6.

Beef samples stored at either 65.6 cm. or 74.3 cm. of N_2 pressure were still fresh in odor and normal in feel after 8 days of storage, while those stored at 60.1 cm. were sticky and odoriferous.

Table 4 shows the total pressures, percentages by volume of carbon dioxide, oxygen, and nitrogen, and partial pressures of the 3 gases calculated from the percentages within each desiccator in Run 6. The partial pressures of N_2 remained almost constant, CO_2 increased, and O_2 decreased as storage time progressed. Changes in oxygen pressure were accompanied by equal, but opposite, changes in carbon dioxide pressure.

TABLE 3

Calculated initial pressures and pressures at removal (3 days) of CO_2, O_2, and N_2 within the desiccators containing meat samples. Run 5. (Ground beef and ground cured ham)

Lot	Desiccator	Calculated initial pressures (cm.) CO_2	O_2	N_2	Pressures at removal (cm.) CO_2	O_2	N_2
A	1	0.1	15.7	66.1	0.4	15.1	59.4
A	2	0.1	13.4	63.5	0.7	12.1	62.3
A	3	0.0	10.2	65.6	0.8	8.8	65.2
A	4	0.0	6.1	69.8	0.5	5.5	68.6
A	5	0.0	2.0	73.9	0.4	1.6	72.8
B	1	0.1	14.6	61.4	0.5	13.7	60.3
B	2	0.1	11.4	64.7	1.4	9.6	63.8
B	3	0.0	8.5	67.5	3.3	5.1	66.8
B	4	0.0	4.2	71.9	1.0	2.9	70.8
B	5	0.0	0.7	75.4	0.6	0.2	74.5

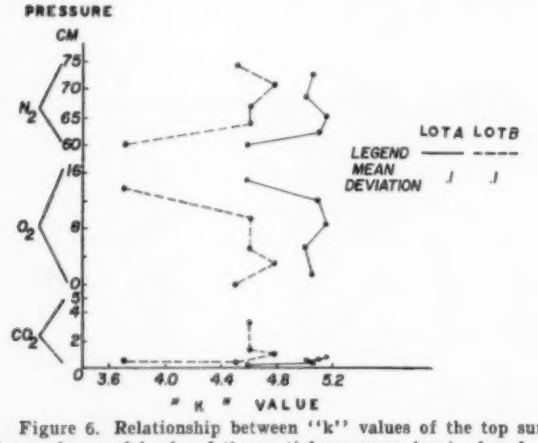

Figure 6. Relationship between "k" values of the top surfaces of ground beef and the partial pressures (cm.) of carbon dioxide, oxygen, and nitrogen at removal. Run 5. ("k" Value = Mean daily decrease in redness for the first 3 days of storage). (Four replicates).

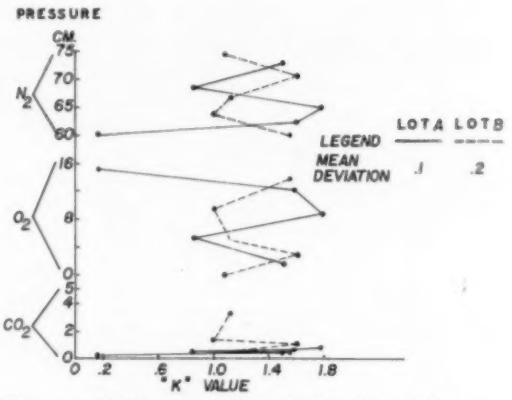

Figure 7. Relationship between "k" values of the top surface of ground cured ham and the partial pressures (cm.) of carbon dioxide, oxygen, and nitrogen at removal. Run 5. ("k" Value = Mean daily decrease in redness for the first 3 days of storage). (Four replicates).

DISCUSSION

Carbon dioxide. In interpreting the results in which the "k" values were plotted against the partial pressures of CO_2, O_2 and N_2, it should be kept in mind that only one removal (at 3 days) was made for each condition of storage. The examination revealed only the initial change in redness (usually a decrease). In

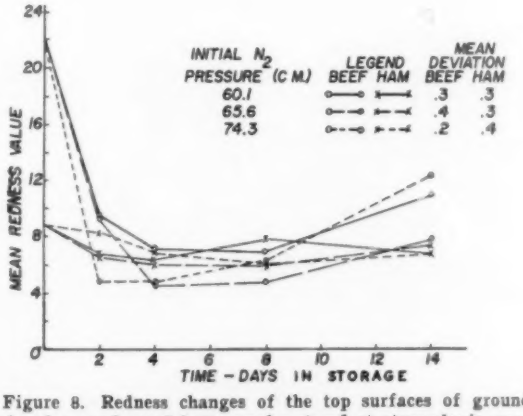

Figure 8. Redness changes of the top surfaces of ground beef and ground cured ham samples stored at atmospheric pressure in atmospheres containing initially 60.1 cm., 65.6 cm., and 74.3 cm. partial pressure of nitrogen. Run 6. (Four replicates).

TABLE 4

Pressure, percentage carbon dioxide, oxygen, and nitrogen (vol.), and partial pressure of carbon dioxide, oxygen, and nitrogen within each desiccator sealed at atmospheric pressure in which the initial partial pressures of nitrogen were 60.1 cm., 65.6 cm., and 74.3 cm. Run 6. (Ground beef and ground cured ham)

Initial nitrogen partial pressure (cm.)	Days in storage	Desiccator pressure (cm.)	% Carbon dioxide	% Oxygen	% Nitrogen	Partial pressure carbon dioxide (cm.)	Partial pressure oxygen (cm.)	Partial pressure nitrogen (cm.)
60.1	0	76.0	0.2	20.8	79.0	0.1	15.8	60.1
	2	73.8	0.3	20.4	79.3	0.2	15.1	58.5
	4	74.9	0.7	20.2	79.1	0.6	15.1	59.2
	8	73.8	16.5	3.2	80.3	12.2	2.3	59.3
	14	75.8	19.5	0.1	80.4	14.8	0.1	60.9
65.6	0	76.0	0.1	13.6	86.3	0.1	10.3	65.6
	2	74.6	0.4	13.2	86.4	0.3	9.8	64.5
	4	75.3	1.1	12.2	86.7	0.8	9.2	65.3
	8	75.2	9.1	4.3	86.6	6.8	3.2	65.1
	14	75.8	13.8	0.2	86.0	10.5	0.1	65.2
74.3	0	76.0	0.0	2.2	97.8	0.0	1.6	74.3
	2	76.1	0.4	2.2	97.4	0.3	1.7	74.1
	4	75.5	0.6	1.8	97.5	0.5	1.4	73.6
	8	75.8	2.4	0.3	87.3	1.8	0.2	73.8
	14	76.5	3.7	0.2	96.1	2.9	0.1	73.5

experiments where fresh and cured meat were stored under 3 sets of conditions for examination at 2, 4, 8, and 14 days, other changes which might occur after the initial decrease in redness could be observed in addition to the short term changes. Examination of fresh beef, stored initially at 0.2, 27, or 72 cm. of CO_2 pressure in a long term experiment, with total pressure at about 76 cm., at 2 days showed that rate of discoloration varied directly with the partial pressure of CO_2 in the storage atmosphere. At 4 days the samples stored at 72 cm. of CO_2 pressure were higher in redness than those stored at 27 cm. High pressures of CO_2 were more effective in maintaining redness after 3 or 4 days of storage than intermediate pressures. Very low pressures of CO_2, however, proved to be most effective in maintaining good color, both from the standpoint of retarding initial discoloration and from the standpoint of holding the color thereafter.

Perhaps in this instance it would be proper to say that the rate of initial redness loss varied inversely with the O_2 pressure, rather than directly with the CO_2 pressure. Likewise, the benefit derived in cured ham color changes from storage under low oxygen pressures and high carbon dioxide pressures, may be due to the low oxygen pressure rather than to high carbon dioxide pressures.

Nitrogen. It is likely that the greater rate of discoloration that occurred when fresh meat was stored under high nitrogen pressures was due to the lowered oxygen pressure rather than to the nitrogen pressure itself. The higher partial pressures of N_2 used in Run 6 produced an acceleration in the rate of discoloration in beef, as did lower partial pressures of oxygen. Samples stored under the highest partial pressure of nitrogen (74.3 cm.) and lowest oxygen pressure (1.6 cm.) exhibited a greater partial return in redness than did samples stored under lower initial nitrogen pressures. Low oxygen pressures apparently favor restoration of redness after initial discoloration.

The beneficial effect of the high nitrogen pressures on the color of cured ham samples for the first 4 days may have been due to the displacement of oxygen by nitrogen in these desiccators.

SUMMARY

Flushing storage atmospheres with carbon dioxide or nitrogen before vacuum storage had, in general, a beneficial effect on color of both fresh and cured meats as compared with samples stored in vacuum without previous flushing.

When fresh beef and cured ham were stored under a pressure of about one atmosphere, and the partial pressure of carbon dioxide was varied from 0.2 cm. to 72 cm., the rate of discoloration of fresh beef varied directly with the partial pressure of carbon dioxide and that of ham inversely with the partial pressures of carbon dioxide. Varying the partial pressures of nitrogen from 59.4 cm. to 74.5 cm., while maintaining a total pressure of one atmosphere, gave similar results with beef, and questionable results with cured ham.

High carbon dioxide partial pressures maintained the color of cured meat better than high nitrogen pressures.

REVIEW OF THE IMPLICATIONS OF THE DATA[5]

Optimal atmosphere for maintaining color. Apparently, from the data, the best way to prevent the initial decrease in redness of fresh meat, is to maintain a high partial pressure of oxygen in the surrounding atmosphere. However, there is a strong indication that no increased benefit would be derived from the use of oxygen tension higher than that of air. On the other hand, increases in oxygen partial pressures never increased the rate of initial loss in redness.

If the degree of redness after about a week of storage is the primary concern, maintenance of a high vacuum in the atmosphere has shown promise in achieving this objective. High storage vacuum accelerated initial discoloration as well as the return of

[5] The review covers the data from Sections II C and II D.

redness. Flushing the atmospheres with nitrogen or carbon dioxide before vacuumizing tended to reduce the amount of discoloration, because more residual oxygen was removed than when the atmospheres were not flushed, thus reducing the likelihood of oxidation to form methemoglobin. If the return of redness is dependent on hemoglobin formation, and no methemoglobin is formed from hemoglobin in the complete absence of oxygen, then the meat pigment in samples stored in an atmosphere which contained no oxygen would be composed entirely of hemoglobin. This might result in the same type of high redness which was attained after periods of about one week in samples stored under vacuuum at 40° F. The pigments in samples stored in the absence of oxygen would not be able to reach the methemoglobin stage, which is responsible for the initial discoloration, and would be in the form of hemoglobin on the application of storage conditions consisting of high vacuum and zero oxygen pressure. Most samples did not return to redness unless vacuum maintenance was a condition of storage.

The maintenance of high redness by storage under oxygen pressures depends on keeping the meat pigment in the form of oxyhemoglobin, whereas the maintenance of redness by storage under high vacuum and zero oxygen pressure is assumed to depend on the formation of reduced hemoglobin.

Fresh meat stored under various partial pressures of oxygen still lost redness. Discoloration, it seems, can be delayed only temporarily by high oxygen tensions. With perfect oxygen permeability of the packaging material, an oxygen tension of 16 cm. would be maximum, but respiration during storage would probably decrease this considerably.

Storing meat under vacuum in the complete absence of oxygen would be a better method of overcoming discoloration, if oxygen could be effectively removed prior to sealing under vacuum and excluded during storage. If traces of oxygen remained in the package, some discoloration probably would occur.

Effect of packaging materials. The thirteen different packaging materials studied affected the color of the meat in different ways. This was to be expected since there is a wide variation in the physical properties of the films, especially in gas permeability.

The samples were sealed under 27 inches of vacuum in all films so that the amount of air remaining inside the packages would be approximately the same in all cases and the resulting color changes in the meat would be due to the properties of the films. The packages were stored at about 40° F. Various types of redness changes were observed with meat stored in the different films.

Cellophane. High redness was maintained in samples packaged in duPont MSAT80 cellophane for about two days, thereafter the samples rapidly lost redness. The good oxygen transmission properties of this film when wet were utilized in placing the wettable side next to the meat. In this instance, the first procedure for retaining redness was used, and the loss of redness after two days is compatible with results by other workers.

Cellulose acetate. This packaging material, which has high gaseous permeability, also maintained good color for the first day or two, then discoloration followed. Substantial dehydration occurred simultaneously with the discoloration, since this film has a high moisture vapor transmission rate.

Cellophane-pliofilm laminate film. There was some initial discoloration of the meat followed by little change or a slight increase in redness. This film has low oxygen transmission properties. Except for the first two days, samples in this film were higher in redness than in the highly permeable films. Cellophane-pliofilm laminate maintained fair redness by means of approximating the second procedure for preventing discoloration. Oxygen tension, it is believed, was reduced to near zero before the conversion of hemoglobin to methemoglobin was far advanced. It is probable that the oxygen tension within the container was almost negligible because of tissue respiration. This explains the partial discoloration and subsequent stability or slight increase in redness that occurred in fresh meat packaged in the film.

Cans. Fresh meat packaged in vacuum sealed cans and stored at about 40° F. decreased initally in redness and then returned to redness between one and two weeks. The oxygen pressure immediately after sealing was quite favorable for methemoglobin formation.

Films vs. cans. Several differences were apparent between the atmospheres in the films and those in the cans after packaging. Only a small amount of air was enclosed in the film pouches at the time of sealing, since the sample occupied almost 100% of their volume. Under these conditions the physical properties of each film were important in influencing the atmospheres developed or maintained in the containers during storage. The oxygen tension maintained next to the meat was dependent both on the rapidity of gas transmission through the film and on the rapidity of oxygen reduction by respiration. The oxygen partial pressure within a film having no oxygen permeability would be reduced quite rapidly since the oxygen used for respiration by the meat and microorganisms would not be replaced from the air outside the film.

In a can, the sample occupied only 20 to 40% of the volume of the container. The can was also impervious to all gases. Since there was a greater volume of oxygen present within the can than within the film pouch, the conversion of hemoglobin to methemoglobin within the can was practically complete. After the oxygen had been used up, reducing conditions within the can permitted the conversion of methemoglobin to hemoglobin, probably with the aid of microorganisms, with the return of good color.

Cured ham. The gas transmission properties of an acceptable film for the storage of cured ham may be postulated from the color changes observed when nonpackaged ham was stored under various partial pressures of carbon dioxide, oxygen and nitrogen.

Cured ham samples maintained their redness best when the oxygen partial pressure of the atmosphere was low, which suggests that a film highly impermea-

ble to oxygen is a prerequisite for good color maintenance of cured ham. This is in accord with the findings of others.

Fresh meat. It is presumed that good color could be maintained in both fresh and cured meat by packaging in a completely impermeable film in the absence of oxygen. The complete absence of oxygen is essential to preserving good color in fresh meat especially during the first 2 or 3 days of storage. The presence of a small amount of oxygen within the package containing cured meat would decrease the redness only slightly.

Although vacuum does not necessarily have to be a condition of storage for cured meat, it seems necessary for storage of fresh meat. Results in this investigation suggest that both fresh and cured meat could be maintained at high redness throughout storage if the meat were stored in a gas impermeable material and flushed with carbon dioxide before sealing to completely remove all oxygen. A 26-inch vacuum should be drawn before sealing on the fresh meat pouches, whole the cured meat does not require vacuum storage.

In the absence of a completely impermeable container, the most nearly impermeable container available might be used to package fresh meat under at least 26 inches of vacuum. In this case, the meat would be expected to decrease somewhat in redness immediately and then remain quite constant in redness or show a slight increase in redness after 4 or 5 days of storage at about 40° F. Under these conditions, it is doubtful that the fresh meat would ever be as high in redness as it was at the time of packaging, but the color should not be undesirable.

In the absence of a completely gas impermeable container, cured meat should be packaged in the most nearly impermeable container available, preferably under at least 26 inches of vacuum. The rate of discoloration would vary directly with the initial quantity of oxygen in contact with the meat. To summarize:

Fresh meat packaged either in air at atmospheric pressure or under vacuum in a container which is very permeable to gases (especially oxygen), for example, cellulose acetate or wet cellophane, maintains high redness for from 1 to 2 days after packaging, then discolors rapidly and remains discolored.

Fresh meat packaged under vacuum in a container slightly permeable to gases, for example, cellophane-pliofilm laminate, loses some redness initially and then remains fairly constant in redness thereafter. The redness established is not undesirable at any time.

If fresh meat were packaged in a slightly permeable container in air at atmospheric pressure, discoloration would become objectionable probably within a day of storage and would either remain low in redness or increase somewhat in redness thereafter.

Fresh meat packaged under vacuum in an impermeable container, such as a can, having a volume capacity much greater than the volume of the meat, loses redness very rapidly, becoming undesirable within one day. In one to two weeks at 40° F., redness returns often to a higher degree than was present at packaging.

If fresh meat were stored in an impermeable container containing no oxygen, high redness or purple-redness would be expected throughout the storage period.

Speculation on identity of pigments. Some workers have found that anaerobes, living pneumococci, and sterile extracts from them reduce methemoglobin to hemoglobin in the absence of oxygen. In the present investigation, it was noted that, as storage vacuum is raised, the time required for redness return in fresh meat is shortened; also that, on exposure to air, meat in the second red color state lightened in color. It seems reasonable to believe that, in the reddening process, microorganisms were instrumental in bringing about a reduction of methemoglobin to hemoglobin.

Possibly, as in cured meat, some compound reacted with methemoglobin to produce a red color in fresh meat in storage. It has been claimed that reducing conditions are necessary to produce the red color peculiar to cured meat.

A procedure for developing red color with a mixture of ascorbic acid and nicotinic acids in association with methemoglobin is described in patent literature. Ascorbic acid establishes reducing conditions through which hemoglobin is produced which combines with nicotinic acid to form a red pigment. Such a process may embody a significant lead to the solution of the present problem.

Flushing the atmosphere with carbon dioxide or nitrogen before final evacuation, followed by storage under high vacuum, resulted in a more rapid return in redness than in samples stored in an unflushed atmosphere. Apparently, reducing conditions are established more quickly when the flush with inert gas is used.

Moisture Condensation and Cold Stored Military Rations[a,b]

(Manuscript received May 2, 1957)

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THERE IS AN ERRONEOUS IDEA that refrigerated spaces are always damp and that goods stored therein are damaged by moisture. This false impression probably derives from the fact that these conditions on occasion do exist and from the further fact that items removed from refrigeration sometimes show moisture condensation.

Actually, refrigerated spaces may be dry and stored goods may lose moisture. For example, loose vegetables dry out when placed in a home refrigerator and, for another, frozen foods dehydrate when improperly packaged. Condensation on items removed from storage may be prevented by protective packaging. If, "sweating," or moisture condensation, occurs on the surface of containers it may cause rusting, staining, wrinkling, loss of shape and other forms of "fatigue". Should it occur on the surface of products it may cause molding, stickiness, loss of luster and degrading otherwise.

Numerous reports *(1, 2, 4, 5, 6, 7)* have shown that refrigerated storage of processed foods extends the shelf-life and in so doing preserves the vitamins, natural color, aroma, flavor and general acceptability of foods. A recent publication *(7)* contained six reports showing that military rations were similarly preserved by low temperature storage. The list of items included meats, dairy products, fruit and vegetable products, baked goods, dehydrated foods, candies, cigarettes, and other general products.

Several previous studies have been made on the amount of moisture condensation or "sweating" on packaged food items upon removal from cold storage, and on the stability of the packages and contents after removal. Heaton *(7)* reported that when Combat Rations in V-board cases were moved from 32° or 47° F. to 70° or 100° F. with 90% relative humidity, condensation occurred immediately on the outside of the cases, but soon disappeared. The condensate was either absorbed, evaporated, or ran off from the cases without affecting the contents. None of it penetrated beyond the waterproof asphalt layer in the case. When rations were moved from −10° to 70° F. with 90% relative humidity, condensation was heavy on the outside of the cases. There was a moderate amount of condensation on the can surface of heavy items, such as canned meats, but none on light items, such as B-Units and accessory packets. However, all of the moisture inside the cases was soon absorbed by the package material or evaporated. All of the rations from −10° F. remained at room conditions (75° F. with 50% relative humidity) for an additional month, and no damage due to moisture condensation was found.

Woodroof and Heaton *(8)* found that condensation on tin cans was due to exposure to ingress of moisture vapor from without the case, proximity to damp packaged surface, and relatively slow warming of product and slow drying of can surface. It was found that condensation, on packaged cans removed from 32° to 70° F. with 90% relative humidity, could be prevented when (a) the carton wall was made impervious to water vapor by aluminum foil, paint, asphalt, or similar material; (b) flaps were glued in place to brace the carton and reduce the bellows effect during handling; (c) openings between flaps and in corners were sealed with waterproof tape; and (d) pads, dividers, absorbers, or desiccants were used to remove traces of moisture which may have entered the package.

Woodroof *(9)* found that moisture condensation and subsequent sugar bloom on candies could be prevented by protective packaging. This consisted of a sealed moisture barrier on the outer surface of the package.

A recent study by Heaton, Kayan and Woodroof *(3)* showed that the major changes in temperature and relative humidity inside cases of canned products occurred during the first three hours after transfer of products into or out of cold storage. The most critical period was the first 20 minutes, during which the relative humidity dropped abruptly when products were placed in cold storage and rose suddenly when they were removed. In the latter case the relative humidity curve reached a sharp point in 20 minutes, receded slightly for about 20 minutes, dropped sharply for the next 20 minutes, and tapered downward to an equilibrium during the next two hours. Condensation formed on commercially packaged canned goods immediately after removal from refrigeration and continued for about two hours, then began to evaporate. Factors which influenced moisture condensation were: the type of package, density of the product, difference between the temperature of the product and temperature of the air, and the relative humidity and movement of the air.

Research to determine the effects on condensation of assembly, storage, and warming-up of rations at various humidity conditions was conducted cooperatively between the Quartermaster Food and Container

[a] Published as Paper No. 314, Journal Series, Georgia Experiment Station, Experiment, Georgia.

[b] This project was sponsored by the Quartermaster Food and Container Institute for the Armed Forces with assistance from The Refrigeration Research Foundation.

Institute for the Armed Forces and the Georgia Experiment Station.[c]

EXPERIMENTAL PROCEDURE

The studies reported here were made on regular military rations delivered to the Georgia Experiment Station for storage as soon as possible after being assembled. In some instances the rations were cold stored, as and when received; in other instances the components were reassembled before storage. Storage was under semi-commercial conditions, in rooms ranging from 400–10,000 cubic feet.

Temperatures and relative humidities were maintained and recorded automatically in some rooms and semi-automatically in others. Readings inside cases of rations were made by sealing electric hygrometer elements in the cases before being placed in storage. Alternating temperatures were obtained by shifting rations from one room to another.

Examinations of each case, the individual packages, and their contents were made both immediately on removal from storage and after reaching room temperature. Condensation was indicated by rusting or staining of cans, wrinkling or staining of flexible packages and paper boards, moisture determinations, and the methylene-blue indicator. Data were taken on the temperature, relative humidity, and air movement, during the periods of assembly, storage and warming-up of the rations. These in turn were related to the amount of condensation. These results are summarized from 3 separate experiments.

Experiment One. This experiment included B-Units of C-rations and Dry-Packs of 5-in-1 Rations, stored at −10°, 70°, and 100° F. Rations were also alternated from −10° to 100° and from 70° to 100° F. at intervals of two weeks and examinations were made each three months for two years.

Experiment Two. The second experiment was conducted on 50 cases of Combat Rations in V-board containers. These were divided into lots and stored at 47° F. with 90% relative humidity, 32° F. with 90% relative humidity, 32° F. with 50% relative humidity, and −10° F. with equilibrium relative humidity.

[c] Contract DA19-129-qm-414, Investigation of Effects of Assembly, Cold Storage and Warm-Up Conditions on Operational Rations.

Figure 1. Rations were removed from refrigerated storage at six-month intervals for careful examination of each component for physical and chemical changes.

Experiment Three. A third experiment included 5-in-1 Rations, Menu 4, (a) held 7 weeks and assembled at 70° F. with 30% relative humidity, 70° F. with 55% relative humidity, and 85° F. with 85% relative humidity; (b) stored at 33° F. with 55%, 65% and 75% relative humidity and air velocity of 100 c.f.m. or higher, for 3, 6, 9 and 12 months; and (c) warmed-up at 70° F. with 30% and 65% relative humidity, and 100° F. with 65% relative humidity for 3 and 30 days.

RESULTS AND DISCUSSION

Following are the results from the 3 experiments together with a brief discussion of each.

EXPERIMENT ONE

B-Units of C-rations and Dry-Packs of 5-in-1 rations were unaffected when moved directly from −10° F. to room temperature. Over a period of 2 years more than 600 transfers of these rations were made from −10° to 72° F. with 60% relative humidity. It was found that about 24 hours were re-

Figure 2. None of the components in this ration was adversely affected by direct removal from −10° F. storage to 72° F. with 60% relative humidity.

Figure 3. After removal from refrigerated storage, tin cans were carefully examined for rust or other indications of moisture condensation.

quired for the temperature in individual rations to equalize after transfer. These rations contained only products of low density; most of the temperature change occurred during the first few hours. The rations were opened after 18 hours and each component was carefully examined. Condensation appeared on the outside of the cases immediately upon removal from the lower temperature, but in all instances it evaporated within 6 hours without damage to the cases or contents.

Combat Rations, in V-board containers, were undamaged when moved directly from −10° F. to room temperature, provided they were not opened until

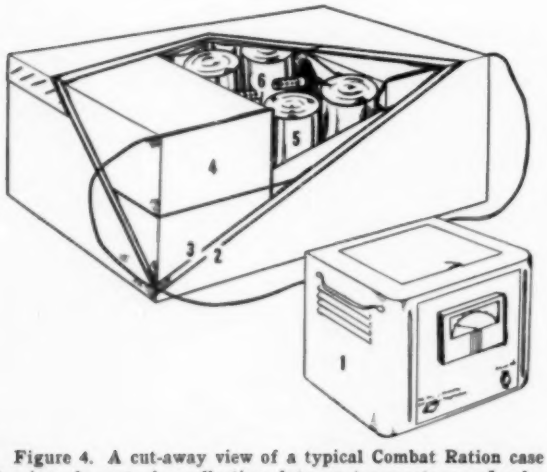

Figure 4. A cut-away view of a typical Combat Ration case showing elements for collecting data on temperature and relative humidity gradients when transferred from one storage condition to another. (1) Aminco Dunmore Electric Hygrometer Indicator with connecting cables; (2) V-board sleeve around the case; (3) case wall made of V-board; (4) boxes of individual rations in Kraftboard; (5) canned products and (6) temperature and humidity indicating elements. A box of this type was very effective in controlling condensation on the contents when transferred from a low to a high temperature.

the latter temperature was reached. Data in Table 1 show that when these rations were removed from 4 storage conditions to 4 warm-up conditions water-vapor condensed and collected on the exterior of the cases, and only small amounts entered the cases through the corners and condensed on the cans. The amount of condensation that accumulated on the rations depended upon the temperature differences between the rations and the warm-up rooms, and the relative humidity of the latter. The amount of and damage from condensation was small; the V-board was an excellent water-vapor barrier, and the packaging materials absorbed a considerable amount of the condensate without damage to the contents.

When Combat Rations were moved from one temperature to another the B-Units changed in temperature at a much faster rate than the meat items, Figure 5. Consequently the meat items remained below the

TABLE 1

Effects of various temperatures and relative humidities on condensation when combat rations in V-board cartons were moved from refrigerated storage to higher temperatures

Storage		Warm-up		Condensation
Temperature	Relative humidity	Temperature	Relative humidity	
°F.	*per cent*	°F.	*per cent*	
47	90	100	90	Slight, exterior only
		100	50	None
		70	90	Slight, exterior only
		70	50	None
32	90	100	90	Slight, exterior only
		100	50	None
		70	90	Slight, exterior only
		70	50	None
	50	100	90	Slight, exterior only
		100	50	None
		70	90	Slight, exterior only
		70	50	None
−10	equilibrium	100	90	Heavy, exterior, moderate on cans
		100	50	Slight, exterior, moderate on cans
		70	90	Slight, exterior, slight on cans
		70	50	Slight, exterior, slight on cans

dew point temperature longer and accumulated more condensation than the less dense B-Units. Throughout these experiments condensation or its effect were not noted on any cans of B-Units.

EXPERIMENT TWO

Temperature and relative humidity gradients of the atmosphere inside cases of Combat Rations moved in and out of refrigerated storage were obtained. Since they all formed the same general pattern, only those for in and out of 33° F. are presented as being representative, see Figure 6. When C-rations were placed in refrigerated storage, the relative humidity inside the cases dropped rapidly for the first 30 minutes and then slowly until a minimum was reached at about 12 hours. Thereupon it rose gradually until it equalized with the room. When rations were removed from refrigerated storage, the relative humidity of the atmosphere within the cases increased

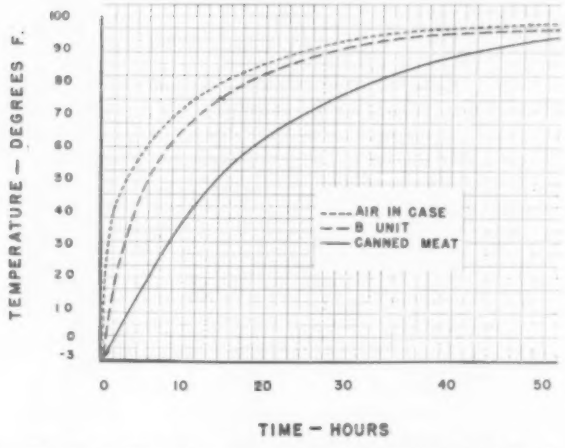

Figure 5. Warming-up rate of Combat Rations in V-board cartons. (a) Internal atmosphere; (b) B-Unit; (c) canned meat. The rate of heat transfer was much slower in the meat items than in the less dense B-Unit items. Condensation was more likely to form on the dense items than on the B-Unit items.

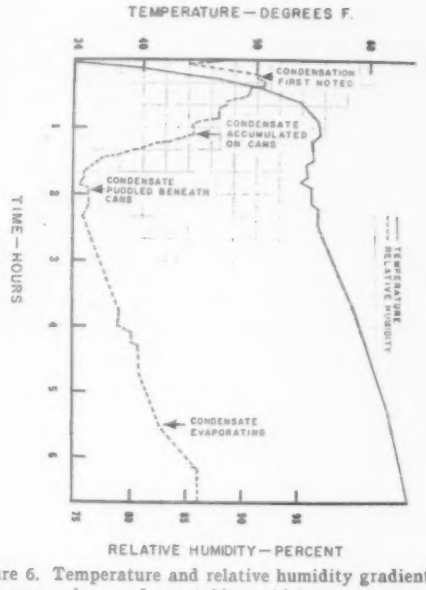

Figure 6. Temperature and relative humidity gradients within RSC cases of canned vegetables, which were removed from 32° F. with 75% relative humidity to a room at 70° F. with 95% relative humidity. Points are indicated on the relative humidity curve when condensation was first noted on the cans, the length of time it continued to form, and when evaporation was noticeable.

rapidly and reached a peak during the first 30 minutes, and then gradually equalized with the room. The maximum and minimum relative humidities reached within the cases depended upon; (a) the relative humidities of rooms to which rations were transferred, and (b) the temperature differences between the rations and the transfer rooms.

EXPERIMENT THREE

V-board cases, sleeves and packing material of 5-in-1 Rations, Menu 4, were practically free of damage, following storage under several conditions. Exceptions were slight rusting and corrosion of straps and staples, prominent glue lines and slight fatigue of dry pack boxes, pads, and dividers. These changes occurred during the warming-up period, increased at elevated temperatures and relative humidities, and were greater after 30 than after 3 days. There was no damage to flexible packages in the ration Dry-Pack.

Condensation of moisture occurred on the exterior surface of V-board cases when the conditions were favorable. It was more prominent on the tops and bottoms of the cases, and only small amounts reached the interior of the cases. Entrance was through the corners where the boards failed to form a complete moisture barrier.

There was slight rusting of cans when stored as described above. It was found that rusting of cans was due to many conditions to which the cans were subjected prior to assembly for storage; and once initiated it increased throughout the period of assembly, storage and warming-up. Rusting occurred on areas of the cans that were unprotected by solder, paint, tin plate or enamel. In some instances areas were left unprotected when the cans were manufactured, in others breaks occurred during handling.

Of 1158 cans that rusted, rust appeared on 134 tops, 158 top double seams, 377 side seams, 1012 wiped areas, 192 bodies, 223 bottom double seams, 126 bottoms, 122 top unions, and 103 bottom unions. Forty-one per cent of the rust spots were on the wiped areas, which was about three times greater than on any other area.

Assembly conditions. Assembly conditions had more influence on rusting of cans than did the storage or warming-up conditions. In rations conditioned and assembled at 70° with 30% relative humidity, 70° with 55% relative humidity, and 85° with 85% relative humidity, the percents of cans that rusted were 13.0, 12.3 and 75.0, respectively. Of 720 cans examined, 245 rusted before or during assembly—37 at 70° with 30% relative humidity; 25 at 70° with 55% relative humidity; and 183 at 85° with 85% relative humidity.

When rations were reassembled all the rust on parts of the cans was considered surface type rust.

Storage. Storage at 33° F. with different relative humidity conditions had little effect on rusting of cans in assembled military rations. During storage of 720 cans for 12 months, rust was initiated on 161 cans—on 52 cans stored with 55% relative humidity, on 53 cans with 65% relative humidity, and on 53 cans with 75% relative humidity. Following storage the number of rusted cans was 1.7, 1.6 and 1.7 times greater than when assembled. The corresponding number of rusted areas on cans was 1.3, 1.8, and 2.0 times greater.

During storage for 12 months at 33° F. and 55, 65, and 75% relative humidity the surface rust observed at the time for assembly changed to pitted rust.

Pitted rust was evident within 6 months, and continued to increase during the remaining 6 months. Also there was some development of surface rust during storage at the 3 relative humidities. There were no significant differences in the number of rusted cans or can parts among the storage relative humidities.

The increase in rusted parts at the higher humidity storage conditions is of interest to the Military. Combat Rations and certain other canned subsistence items are to be stored for 5 years in cold storage at 33 ± 1½° F. Based on the above and on the incidence of pitted rust found on cans following the storage period, there is some reason to believe that there is a break point somewhere between 55 and 65% relative humidity where corrosion materially increases—even at 33° F. Whether or not this increase would result in serious deficiencies after 5 years of storage or would materially affect the subsequent performance of the canned items during field use cannot be predicted. It was originally intended to carry a portion of the stored rations for 5 years, but curtailment of funding made this impossible.

Warming-up Conditions. Warming-up conditions influenced condensation on the cases and contents. Results on the occurrence and ill effects of condensation on 5-in-1 Rations held for 3 and 30 days after removal from refrigerated storage are summarized in Table 2.

TABLE 2

Effect of temperature and relative humidity of the warm-up rooms on the extent of and damage from moisture condensation on five-in-one rations moved from 33°

Warm-up			Condensation on			Rust on 1080 cans examined	
Conditions		Time	Exterior	Interior	Packing material	Cans	Areas
°F.	r.h.	*days*				*No.*	*No.*
70	30	3	Slight	Slight	Very slight	34	34
		30	Slight	Slight	Very slight	68	163
70	65	3	Moderate	Moderate	Slight	51	105
		30	Moderate	Moderate	Slight	93	302
100	65	3	Moderate	Moderate	Moderate	62	156
		30	Heavy	Moderate	Moderate	88	411

After 3 days of warming-up a total of 40.7% of the straps and 31.6% of the staples were rusted. Corresponding percentages after 30 days' warming-up were 53.6 and 66.7, respectively. Although rusting increased during warming-up, it was not serious enough to damage the sleeves or cases.

Slight fatigue was observed in 2 rations warmed-up for 3 days, one at 70° F. with 30% relative humidity and one at 70° F. with 65% relative humidity. Glue lines were prominent in 3 rations warmed up for 3 days, one from each warming up condition, and 14 rations warmed up for 30 days (3, 6, and 5 rations, respectively, at 70° F. with 30% relative humidity, 70° F. with 65% relative humidity and 100° F. with 65% relative humidity). Rust stained can rings occurred on the lower surface of the pad of 4 rations warmed-up for 30 days at 100° F. with 65% relative humidity.

Slight fatigue occurred in 21 Dry-Pack boxes, seven from each of the 3 warming-up conditions (8 after the three days, and 13 after the 30 days warming-up periods). Glue lines in the interior of dry pack boxes were prominent in 25 rations, 8 in those warmed-up for 3 days, and 17 in those warmed-up for 30 days.

None of the packaging materials (envelopes) for products in the dry pack boxes had been adversely affected.

Of 1080 cans examined it was found that rust was initiated on 396 during storage and warming-up. Of the 396 rusted cans, 102 were from rations warmed-up at 70° F. with 30% relative humidity; 144 at 70° F. with 65% relative humidity; and 150 at 100° F. with 65% relative humidity. For the 3-day warming-up period at these 3 conditions, the number of rusted cans was 34, 51, and 62; the number of rusted areas on the cans was 34, 105, and 156 more than when assembled. For the 30-day warming-up period corresponding increases were 68, 93, and 88 rusted cans, and 163, 302, and 411 rusted areas.

When rations were warmed-up for 3 days and for 30 days following refrigerated storage, there were definitely fewer rusted cans, and surface rusted and pitted rusted can parts in rations that had been stored at 33° F. with 55% relative humidity, than in those that had been stored at the 2 higher humidities. Both surface and pitted rusted areas increased during the 30 days' warming-up period. During storage and warming-up only 7.2, 15.2 and 13.8% of the can parts rusted from the 55, 65, and 75% relative humidity storage, respectively.

Condensation and rusting of tin cans was related to the kind of cans and products. Condensation on cans was closely associated with rusting, and was most severe on the type of cans used in 5-in-1 Rations for bread, jam, corn, and apple-sauce. It was worse on unpainted cans and with heavy items such as apricots, jam, corn, meat balls and spaghetti, and peas. When rations, which were dusted with methylene blue, were warmed-up for 3 days at 70° F. with 30% relative humidity, 70° F. with 65% relative humidity, and 100° F. with 65% relative humidity there were 23 cans in 4 rations, 29 cans in 6 rations, and 39 cans in 6 rations that showed condensation. No condensation was noted on cans in rations from the 33° F. and 55% relative humidity storage condition.

CONCLUSIONS AND SUMMARY

From these experiments it appears that moisture condensation or "sweating" may occur on military rations at any time they are exposed to a warmer temperature; i.e., removal from storage to a humid, warmer atmosphere; or upon sudden admission of warm, humid air to the holding spaces. However, the usual ill effects associated with moisture condensation have not been found to be of major importance in refrigerated storage of assembled Combat Rations. The

selection and use of good packaging materials are the reasons for this good response.

Under prevailing practices, condensation is related to one or more of the following: the nature of the items, the type of package, storage conditions before assembling, and the conditions for assembling, storing and warming-up.

Moisture condensation was found to be associated with the density, heat capacity and heat conductivity of the product. It was worst on such products as canned apricots, corn, meat balls and spaghetti, and was least on canned soluble coffee, dry cream and cookies. In general, products with the highest water content, or with the heaviest syrups, had the most condensation.

Moisture condensation was more abundant and caused greater damage to tin cans than to any other packaging material. Some condensation formed on the outside of cases, on pads and dividers, and on flexible packets, but soon evaporated with little or no ill effects. Damage to the cases was confined largely to the metal straps and staples.

It was found extremely important to store products in tin cans free of rust—either surface or pitted rust. Rust, once initiated, increased during the periods of assembly, storage and warming-up. Initiation of rust was related to imperfections in the cans, mechanical injury to the cans, presence of corrosive substances and hygroscopic materials on the cans, as well as to moisture condensation.

Rations destined for refrigerated storage should be especially selected and handled—that is, the cans should be free of rust, scratches, or other damages and other package materials should be as moisture impermeable as is practical. Rations may be assembled before or after storage, but, on the basis of the findings, preferably the latter. They should be handled during pre-storage under conditions where fluctuation in temperature and humidities is as small as possible. Rations should be stored at suitable temperatures and at low humidities, with only slight variation in either. Finally, they must be allowed to reach room temperature before opening.

LITERATURE CITED

1. Guerrant, N. B., Vavich, M. G., and Dutcher, R. A. Nutritive value of canned foods. XIII. Influence of temperature and time of storage on vitamin content. *Ind. Eng. Chem.*, 37, 1240–1243 (1945).
2. Guerrant, N. B., Fardig, O. B., Vavich, M. G., and Ellenberger, H. E. Nutritive value of canned foods. XXVII. *Ind. Eng. Chem.*, 40, 2258–2263 (1948).
3. Heaton, E. K., Kayan, C. F., and Woodroof, J. G. Heat and vapor movement on refrigerated packaged goods. *Refrig. Eng.*, 65 (8), 42–47, 64–69 (1957).
4. Moschette, D. S., Himman, W. F., and Holliday, E. G. Nutritive value of canned foods. XXII. Effect of time and temperature of storage on vitamin content of commercially canned fruits and fruit juices (stored 12 months). *Ind. Eng. Chem.*, 39, 994–999 (1947).
5. Monroe, K. H., Brighton, K. W., and Bendix, G. H. Nutritive value of canned foods. XXVIII. Some studies of commercial warehouse temperatures with reference to the stability of vitamins in canned foods. *Food Technol.*, 3, 292–299 (1949).
6. Sheft, B. B., Grisfeold, R. M., Tarlowsky, E., and Holliday, E. G. Nutritive value of canned foods. XXVI. Effect of time and temperature of storage on vitamin content of commercially canned fruits and fruit juices (stored 18 and 24 months). *Ind. Eng. Chem.*, 41, 144–145 (1949).
7. *Storage and Handling of Semiperishable Subsistance Items, A Symposium.* Office of the Quartermaster General, Research and Development Division, Washington. 1955.
8. Woodroof, J. G., and Heaton, E. K. Protective packaging of foods against moisture condensation. *Food Technol.*, 9, 510–518 (1955).
9. Woodroof, J. G. Protective packaging of candies. *Package Eng.*, 1 (5), 9–13 (1955).

Variation in Preference Ratings for Foods Served at Meals[a]

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COMPETITION among the food industries has brought about increasing awareness of the importance of consumer likes and dislikes, but there has been considerable lag in the development of adequate methods of measuring these variables and relating them to consumer acceptance. It is generally agreed that the prediction of acceptance requires the measurement of preferences, but there is less concurrence on how to answer such important questions as "Whose preferences?", "In what situations?", and "Under what conditions of control?" The answers are often determined arbitrarily rather than through analysis of the particular problem under consideration.

In many cases this is due to lack of knowledge about the situations which are utilized for testing, and about how changes in test conditions may affect results. Expressed preferences may sometimes appear highly variable, but they are also characterized by definite elements of stability. It is reasonable to assume that much of the variation is systematic, and therefore can be measured or accounted for in test design. The present experiment was designed to test this assumption by obtaining information about the factors affecting food preferences in a particular environmental situation. The specific findings will be applicable only under the same circumstances, but it is believed that the approach has general validity.

The situation investigated was that represented by a normal meal in Army mess-halls—a field situation as opposed to controlled laboratory preference tests. Preference results obtained here should be more valid as predictors of actual food acceptance than the results of laboratory tests simply because it represents normal feeding and, potentially at least, more of the conditions that might influence actual acceptance are allowed to operate without restrictions. On the other hand, one might expect results to be less reliable because of this very lack of control. The normal meal situation can play an important role in Quartermaster Corps food research, since it may be used as the second stage, following laboratory preference tests, in the pretesting of new food items for acceptability. Therefore it was important to learn its characteristics as an aid in test design and data interpretation.

The experiment had the general objectives of estimating the extent of variation in preference for a constant food that might be encountered in repeated testing and locating the sources of the variation. It was necessary to be selective in regard to the sources, since preference might be affected by a great many factors, and only a few could be included in one experiment. The following factors were investigated: (1) mess-hall, or, to be more exact, subject group, since the men constantly eat at the same mess hall, (2) meal (breakfast, dinner, or supper), (3) day of the week (Monday, Wednesday, or Friday), (4) successive weeks during the experiment, and (5) questionnaire form (whether one, two or four foods were to be rated).

PROCEDURE

A single test food was served repeatedly at regular meals in nine mess halls at Fort Lee, Va. in late August 1953, the 5 factors being varied according to a pre-planned pattern. Each time it was served, preference ratings were obtained from a sample of the men eating at the meal.

The test food was orange juice of reasonably good quality, and was all prepared from a single production lot of dehydrated juice using a uniform procedure. It was served chilled (about 50° F.) either in pitchers on the tables or on the serving line, according to normal practice in the particular mess. The temperature increased about 10° F. during the course of a meal but the change was fairly uniform between messes.

Nine messes, each of which fed one Company of about 200 men, were randomly selected to participate. The type of duty which the men were engaged in was uniform both among Companies and throughout the period of the test. It was also rather strenuous since practically all of the men in each Company were basic trainees. The testing was done by military test teams from the Quartermaster Research and Engineering Command Field Evaluation Agency at Fort Lee, Va. Respondents were obtained by randomly selecting 30 of the men served at each test meal. While a selected respondent was eating, the test monitor oriented him by means of a simple, uniform talk, then gave him a questionnaire and instructed him in its use. The test monitor remained available to answer questions.

The questionnaires which were used were similar to the laboratory form, as described by Peryam and Pilgrim *(2)*, but also provided the subject the opportunity to check *Did not try* as an alternative to rating any particular food. There were 3 different forms which included scales for rating 1, 2, or 4 foods, respectively. The food names were printed at the head of the scales prior to testing. Orange juice appeared on all forms; the other item(s) to be rated were selected by the test team from the menus for the test meals.

The design used was a 1/27th replicate as described by Kempthorne *(1)*. Its operational detail is shown in Table 1 which gives the combination of factors for each session. It

[a] This paper reports research undertaken at the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 643 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or endorsement of the Department of the Army.

will be noted that each of the 9 messes was tested 3 times, and that these tests were on 3 different days of the week, one at each of the 3 daily meals, and with 3 different questionnaire forms. Also, each mess was tested once in each of the three weeks of the study.

The mess variable requires further explanation. The population of Company-size messes available at Fort Lee was determined and 9 of these were selected randomly. Two pseudo-variables, U_1 and U_2, were established, each at 3 levels, which together define the mess variable. The 9 messes were randomly assigned to the cells developed from the 3 levels of U_1 and U_2. Once this was done, the combinations of day, form, meal, and week of testing were determined by the confounding relation defining the design, which, however, is not shown. The analysis of variance table indicates the confounding of main effects and interactions with other main effects and 2-factor interactions (considering mess as one factor). Confounding with 3 or more factors is not shown.

RESULTS AND DISCUSSION

Table 1 presents the basic data in the form of the mean preference rating for each session, obtained by assigning the values 1–9 to the scale categories beginning at the *dislike* end *(2)*. *N's* less than 30 were due either to spoiled questionnaires or to a subject's not having tried the test food. The 27 means show considerable variability, ranging from 5.79 to 8.29. Statistically, this range of 2.50 scale points is very significant, despite the relatively small number of subjects at each test session. Evidence from other experiments *(3)* shows that differences of this order mean much more than just preference trends; usually they may be taken as indicating important differences in objective food behavior. In Table 2 the data are grouped in different ways to show the effect of each category of each variable.

Table 3 presents the analysis of variance for the entire experiment. An analysis of variance using all of the data would have been arithmetically very difficult because of the unequal number of ratings at various sessions. Therefore, for purposes of this analysis, ratings were discarded from various sessions in such a way that there were an equal number for all sessions while the mean and standard deviation remained invariant.

The effects of day, week, and questionnaire form were clearly insignificant. Little more can be said about them except to qualify the findings by taking into account the limited ranges of the variables. The day variable did cover the entire range which is practical for pretesting. Food tests are never run on week-ends simply because so many conditions may change at that time. The variation in number of foods included on the questionnaire was a minor, though practical, one. It is worth while to have demonstrated that stated preferences will remain constant in spite of this difference in the rating task; however, we obviously cannot conclude that other changes such as, e.g., changes in instructions or description of the scale categories would have no effect. Similarly, there was practical value in showing that no effect could be attributed to the general time factor (week) over a 3-week period, since most pretests are short range affairs. However, logic warns us against the general conclusion that we need never expect such effects. There may be changes in the weather, long-range seasonal changes, changes in personnel or their type of duty, or changes in morale. We can suppose

TABLE 1

Preference ratings for orange juice obtained at meals over a period of three successive weeks

Session	Mess	Week	Day[1]	Meal[2]	Questionnaire[3]	N	Mean rating
1	A	1	M	B	1	24	7.00
14	A	2	W	D	4	29	7.07
27	A	3	F	S	2	28	8.29
7	B	1	F	B	4	29	7.38
11	B	2	M	D	2	29	7.21
24	B	3	W	S	1	29	7.07
4	E	1	W	B	2	32	7.28
17	E	2	F	D	1	27	6.89
21	E	3	M	S	4	29	7.55
2	F	1	M	D	1	29	7.00
15	F	2	W	S	4	27	7.00
25	F	3	F	B	2	31	6.06
5	G	1	W	D	2	28	5.79
18	G	2	F	S	1	29	6.69
19	G	3	M	B	4	21	6.95
9	I	1	F	S	4	29	7.38
10	I	2	M	B	2	27	6.37
23	I	3	W	D	1	26	7.42
3	K	1	M	S	1	29	7.76
13	K	2	W	B	4	24	6.50
26	K	3	F	D	2	29	7.10
6	L	1	W	S	2	29	7.45
16	L	2	F	B	1	27	7.30
20	L	3	M	D	4	28	7.14
8	M	1	F	D	4	29	8.24
12	M	2	M	S	2	30	8.17
22	M	3	W	B	1	26	7.19

Grand mean—all sessions.....7.16
Range of session means.....2.50

[1] Monday, Wednesday, Friday.
[2] Breakfast, Dinner, Supper.
[3] Number of foods appearing on the questionnaire for the subject to rate.

TABLE 2

Preference ratings for orange juice obtained by grouping test meals for each category of each variable

Variable	Category	No. of test sessions	No. of ratings	Mean rating	Range of means
Day	Monday	9	246	7.26	0.28
	Wednesday	9	250	6.98	
	Friday	9	258	7.24	
Questionnaire	1 food	9	246	7.13	0.19
	2 foods	9	263	7.08	
	4 foods	9	245	7.27	
Week	First	9	258	7.26	0.23
	Second	9	249	7.03	
	Third	9	247	7.16	
Meal	Breakfast	9	241	6.89	0.58
	Dinner	9	254	7.10	
	Supper	9	259	7.47	
Mess	A	3	81	7.47	1.49
	B	3	87	7.22	
	E	3	88	7.25	
	F	3	87	6.67	
	G	3	78	6.40	
	I	3	82	7.06	
	K	3	82	7.16	
	L	3	84	7.30	
	M	3	85	7.89	

TABLE 3

Analysis of variance based on preference ratings for orange juice obtained at 27 different meals

Variable	Degrees of freedom	Sum of squared deviations	Mean square	F-ratio
Meal ($= FU_2$)	2	32.91	16.46	4.45[1]
Day ($= FU_1 = WF^2 = WU_1 = MU^2_1U_2$)	2	9.54	4.77	1.29
Form ($= DU_1 = MU_2 = WD = WU^2_2$)	2	2.65	1.32	<1
Week ($= DF^2 = DU^2_1 = FU^2_1 = MU_1U_2$)	2	6.40	3.20	<1
Mess	8	86.13	10.77	2.91[2]
MF^2 ($= MU^2_2 = FU^2_2$)	2	9.91	4.95	1.34
MD ($WU_2 = MU_1U^2_2$)	2	.35	.18	<1
MU_1 ($= WU^2_2$)	2	2.98	1.49	<1
MU^2_1 (DU^2_2)	2	36.09	18.04	4.88[2]
$DU_2 = MU^2_1U^2_2 = MW$)	2	1.91	0.95	<1
Within Cell (error)	540	1998.10	3.70	
Total	566[3]	2186.96		

[1] Significant at 5% level.
[2] Significant at 1% level.
[3] N's of all test sessions were reduced to 21 for purposes of this analysis.
F—Questionnaire form; M—Meal; D—Day; W—Week; U_1, U_2—Components of mess.

that the present negative result was dependent on maintaining a temporary stability in regard to such relevant factors.

The effects of mess and meal were both significant. Mess had the greatest absolute effect, the means varying over a range of 1.49 scale points (see Table 2), and was significant at the 1% level. Such group differences seem to be typical of preference testing. Similar effects can nearly always be found whether one considers laboratory preference and trained panel tests or various field situations. On the whole, group effects are probably the most troublesome factor that must be dealt with in planning tests and interpreting results, since their causes are not precisely known. Much of this effect, perhaps all of it in laboratory testing, may be due to sampling variations within a population where preference itself is quite variable. However, additional factors are probably involved in the present situation. Each mess has a different group of food service personnel with varying skills and motivations, so that there will be opportunities for differences in food preparation and serving. The individuals constituting each group eat together and are usually together in many other situations. Also there may be basic differences among the groups of men. For example, they may be assigned to different types of duty or attitudes may develop in different patterns for other reasons. Such factors could cause physiological or psychological differences between groups which could affect food preferences. Even though a relatively large and significant amount of variation in preference was attributable to mess in this experiment, it is possible that this represents only a part of the potential range, since the number of messes was small, they were all at the same post, and all of the men were assigned to the same type of duty.

The variation due to meal is significant at the 5% level and, again, the range of 0.58 of a scale point may be considered important. One might expect differences in preference for many foods depending on the meal at which they are served, because custom dictates that certain foods are more appropriate for some meals than for others; however, this does not explain the present results. Orange juice would be considered as more appropriate for breakfast than for any other meal, yet here the breakfast mean lies at the low end of the range. Our search for explanations has to be speculative. The reason may have been the novelty of being served the drink at an unexpected time. Perhaps a better reason lies in the fact that the study was run during hot weather and most of the men were engaged in strenuous basic training activities. This suggests the explanation that the cool beverage had a greater refreshment value in the evening because the men were more thirsty after work. Preference was *not* found to be significantly correlated with temperature or humidity as measured at meal times or with daily average temperature or humidity; however, no data were available on relative degrees of activity so that a test of this factor was not possible.

The only interaction which proved to be significant was that between meal and one of the components of mess (MU^2_1), which is confounded with the interaction of day and the other component of mess (DU^2_2). It is impossible to make any specific interpretation of the finding on the basis of the present experiment.

This experiment was concerned with only one food, and one cannot assume that the pattern of variation established would be typical of all items. For example, it is possible that preference for many foods would remain constant from one meal to another, and that preference for a limited number of foods would vary during the week because of customs of serving. Here we did not investigate even a small sampling of foods, but had to be content with intensive examination of only one; however, since variation was found with orange juice, it would seem likely to occur with other foods.

The fact that one must expect such variation does not mean that the normal meal situation cannot be used for pretesting.[3] Pretesting is concerned more often with establishing relative preference values within a group of similar items than it is with establishing absolute levels of acceptance. Typical problems might be: comparing dehydrated with fresh orange juice, comparing dehydrated potatoes made by different processes, or comparing a number of canned meat items. It is reasonable to assume that preference for similar items will be affected in the same way as elements in the test situation are changed, e.g., as the test moves from one mess to another, from dinner to supper, or from one week to the next. Whenever this is true the normal meal situation can safely be utilized to establish relative preference values simply by designing the test so that all items are subjected to the same set of conditions.

SUMMARY

A single food was tested for preference at regular meals in military mess-halls over a period of three weeks. The total range of variation was large, a result which suggests that a preference rating established in a single test of this type may be quite unreliable. The test design obtained information about the effect of five different factors on preference. Of these, the effects of mess hall (subject group), and of meal of the day were significant. The effects of questionnaire form, day of the week, and week itself were not significant within the ranges investigated.

This information has been useful in guiding the design of pretests utilizing the normal meal situation. It is suggested that the same general approach could be used to advantage to explore and evaluate any preference survey method.

LITERATURE CITED

1. Kempthorne, Oscar. *Design and Analysis of Experiments.* 1952. Wiley, New York, N. Y., pp. 390–429.
2. Peryam, D. R., and Pilgrim, F. J. The hedonic scale method of measuring food preferences. In *Methodology of Sensory Testing—A Symposium.* 1957. Pages 9–15. The Garrard Press, Champaign, Illinois.
3. Schutz, H. G. Preference ratings as predictors of food consumption. *Am. Psychologist*, 12, 412 (1957).

Antioxidant in Malt and Malt Sprouts[a]

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TRADITIONALLY MALT IS USED primarily as basic material for fermented and distilled beverages and secondarily as flavoring agent or enzyme source for baked or other cereal products. New applications for malt consonant with modern food technology might be made available, however, by recognition of malt properties in addition to the established carbohydrate, protein, enzymatic, and flavoring values. Taüfel and Köchling *(6)* investigated the superior stability of coffee substitutes prepared from highly roasted malt as compared to highly roasted barley. They reported that "coffee-malt" exhibits antioxidant activity which originated in malting and was enhanced by roasting. Because of its dark color and high flavor, "coffee-malt" cannot be easily adapted to more general antioxidant applications. This is a report of preliminary experiments which show that normally-dried commercial malts exhibiting light color and bland flavor as well as malt rootlets contain antioxidants capable of stabilizing food oils. The antioxidant is shown to be operative in flours prepared from malt materials and is effective both at somewhat elevated temperatures as well as at room temperatures. Extracts prepared from malt "sprouts" (malt rootlets), which are a by-product of the malting process, exhibited activity at concentrations customary for pure chemicals used in commercial antioxidant practice.

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 14, 1957.

MATERIAL AND METHODS

Flours. Flour samples of distillers', brewers', "high dried", and caramel malts were prepared from commercial malts of the current year's production. These malts differed primarily as a result of the temperature and rate of kilning or drying of the finished malt. Thus the final drying temperatures of distillers', brewers', "high dried", and caramel malts were approximately 110° F., 190° F., 210° F., and 400° F. respectively. Malts were pearled in a wire brush laboratory mill and ground in a hammer mill to pass through a 1/16 inch round perforation exit screen. A malt rootlet flour was prepared also by similarly grinding the commercial by-product known as malt sprouts.

Extracts. Extracts of malt sprouts were prepared from the commercial material by 4-hour extraction in a Soxhlet extractor using water, methanol, ethyl acetate, ligroin, or chloroform as extractants. The above solvents extracted 36.0%, 12.3%, 2.3%, 0.6%, and 1.3% of the sprouts weight respectively. When tested for antioxidant activity using extract weights equivalent to a constant weight of original sprouts, it was found that the methanol extract was most active and thus most effective for extraction.

Larger scale laboratory preparations of malt sprout extracts were made by 5 cycles of alternate, (a) suspension of malt sprouts for 15 minutes in methanol (methanol weight/sprouts weight = 2), (b) centrifugation and (c) decantation of the supernatant. The extracted material was then recovered as a solid by evaporating the methanol or by precipitation with either two volumes of chloroform or ten volumes of acetone. Solvents were evaporated from the collected precipitate in a stream of carbon dioxide. Yield of methanol extract approximated 10 to 15% of the weight of sprouts originally used.

Oils and fats. Commercial samples of corn oil, cottonseed oil, and prime steam lard were used in tests of antioxidant activity.

Antioxidant activity test. The presence of antioxidant was determined from a comparison of the rate of development of peroxides in control and treated oil samples.

For tests reported in Tables 1, 4, and 5, one hundred grams of oil, untreated control or containing various amounts of added malt products, were placed in a 250 ml. Erlenmeyer flask. Flasks were attached to a manifold and air or oxygen was introduced into the oil through capillaries of 1½ inches length and 0.5 mm. diameter inserted to touch the bottom of the flask. Approximately 500 ml. gas per minute was bubbled through the samples during the entire course of the experiment. Depending upon the specific experiment, aeration was performed at room or regulated elevated temperatures. Periodically 2 cc. samples were removed from the aeration flasks, centrifuged in a clinical centrifuge and analyzed iodemetrically for peroxides by the method of Stuffins and Weatherall *(5)*. Peroxide value is given as milliliters of 0.002N sodium thiosulfate consumed for 1 g. of oil in the iodometric titration. In the absence of interfering substances, each integral amount of the peroxide value so expressed would equal 2 milliequivalents of peroxide per 1000 g. of oil.

Stability tests reported by data in Tables 2 and 3 were determined by the method of Blank *et al. (1)*, generally referred to as the AOM stability.

RESULTS AND DISCUSSION

In a prolonged stability test at room temperatures, it was shown that the addition of various malt flours inhibited accumulation of peroxides in corn oil (Table 1). Compressed air was bubbled through the oil samples during the 160 day course of the experiment and the samples were at room temperatures, 25° C. ± 5° C. It is apparent from the results, particularly the 160-day values, that the malt flours exhibited a pronounced antioxidant effect. Antioxidant potency correlated with malt drying temperature; higher drying temperature of malt lowered antioxidant effectiveness. Malt sprout flour showed definite antioxidant activity; however, it was less than that found for any type of malt.

TABLE 1

Antioxidant properties of malt and malt sprout flours at 25° C. ± 5° C.

Corn oil plus additive	Peroxide value			
	Initial	88 days	137 days	160 days
None, Control	1.40	8.80	17.20	23.18
0.013% NDGA	1.25	8.78	12.57	15.05
0.027% NDGA	1.30	7.43	10.93	12.83
10% Distillers' Malt Flour	1.05	3.43	2.19	3.40
20% Distillers' Malt Flour	1.10	2.98	1.55	2.00
10% Brewers' Malt Flour	1.25	3.70	2.94	4.78
20% Brewers' Malt Flour	0.95	1.83	1.61	2.55
10% "High Dried" Malt Flour	1.25	2.48	2.98	5.13
10% Caramel Malt Flour	1.55	3.30	3.80	5.40
10% Malt Sprout Flour	1.48	4.05	9.85	14.30

Many of the applications of antioxidants in fats require effectiveness at the higher temperatures encountered in baking, cooking or unfavorable storage. Stability tests performed at higher temperatures afford not only time acceleration but also a judgment of antioxidant activity in heated fat. Table 2 lists the AOM stability values of lard, and lard which had been treated with malt and malt sprout flours. Under the conditions of the test the fat is held at 97.7° C. and thus the marked antioxident effect of malt products in this test indicates heat stability. Food uses, however, may require stability under conditions of heat in the presence of moisture and this will require further investigation.

TABLE 2

Antioxidant effect of various malt flours on lard at 97.7° C.

Addition	AOM stability, hr.
None, Control	4.5
10% Distillers' Malt	22.5
10% Brewers' Malt	19.4
10% Caramel Malt	13.0
10% Malt Sprouts	13.0

The antioxidant effect of malt flours is proportional to their concentration in the fat. This is shown by the data of Table 3 which lists the AOM stability values of lard containing 0 to 30% brewers malt or malt sprout flours. The activity of the malt flour is approximately twice that of malt sprouts.

Extracts of malt products which showed enhanced antioxidant activity were prepared by extraction of malt sprouts with methanol followed by precipitations of solutes with chloroform or acetone. As measured by inhibition of rate of peroxide accumulation in oxygenated corn oil (Table 4), 0.01% concentrations of such dried extracts showed marked antioxidant activity.

TABLE 3

Influence of concentration of malt flour on AOM stability of lard

Concentration of additive	AOM—hr.	
	Brewers' malt	Malt sprouts
0	4.5	4.5
5%	13.7	10.0
10%	22.5	13.0
15%	34.0	16.5
20%	47.6	26.1
25%	54.5	30.5
30%	70.0	39.0

Undoubtedly a factor affecting the antioxidant activity of the malt products is the solubility or extractability of the active principle into heated oil which is shown in the following experiment. Five per cent of dried extract prepared by methanol extraction of malt sprouts and vaporization of solvent (cf. materials section) was suspended in corn oil. Oil extractions both at room temperature and 100° C. as shown in footnotes to Table 5 were then made of the malt sprout extract. Table 5 presents the peroxide values found for the oil extracts upon treatment at 97–103° C. with oxygen bubbling through the oil. The low peroxide value of the heated oil extract points up

TABLE 4

Inhibition of peroxide accumulation in corn oil at 100° C. by .01% malt sprout extracts

Time—hrs.	Peroxide values		
	Control	Extract A .01%	Extract B .01%
2	2.80	2.58	2.45
5	9.13	5.10	3.60
8	19.88	11.60	10.60
10		19.20	18.35

Extract A—Chloroform precipitate of methanol extract of malt sprouts.

Extract B—Acetone precipitate of methanol extract of malt sprouts.

TABLE 5

Peroxide values of heated corn oil extracts of a malt sprout antioxidant preparation[1]

Sample	Peroxide value after heating sample at 97–103° C. for:		
	2 hr.	*6 hr.*	*10 hr.*
Corn oil, Control	1.9	16.0	32.4
Room temperature extract[2]	2.1	12.0	37.0
100° C. extract[3]	1.4	2.1	3.3

[1] Prepared by methanol extraction of malt sprouts followed by evaporation of solvent.

[2] 5% of antioxidant preparation suspended in corn oil 30 minutes at room temperature, allowed to stand overnight, and removed by centrifugation.

[3] 5% of antioxidant preparation suspended in corn oil at 100° C. for 30 minutes, allowed to stand overnight, reheated for 2 hours at 100° C. and solids removed by centrifugation.

the marked effect of hot oil in dissolving the antioxidant.

In this preliminary investigation no attempt was made to isolate or chemically characterize the antioxidant substances responsible for these observations. Substances of known antioxidant properties can be anticipated to occur in malt—tocopherols, phytic acid, phosphatides, and reductone-like substances. The presence of tocopherols is assumed by analogy to other cereal seeds *(2)*. Reductones have been postulated in malts and are considered to influence beer stability *(4)*. The various antioxidant substances may function in a natural synergistic fashion to enhance overall activity. Further work is proceeding on isolation and identification of the antioxidants of malt.

The peroxide values used in this study to gauge oil stabilization, although indicative, are not sufficient to measure flavor stabilization. Measurement of flavor stabilization requires organoleptic evaluations. Preliminary trials using a taste panel to evaluate the prevention of rancid flavor in potato chips by dusting chips with malt flour have shown promise *(3)*. It is of interest to note that at an effective level of malt the flavor of the fresh chips was not perceptibly altered by this treatment.

It is obviously premature to discuss extensive food applications of malt products as antioxidants. All other factors being equal, however, there is an inherent security as to lack of toxicity in the stabilization of food by admixture with a natural wholesome food such as malt. A further advantage of malt, which is available in a variety of forms, is that it may provide in addition to antioxidant activity, flavoring, enzymatic activity, and coloring to the degree desired.

SUMMARY

Preliminary experimental evidence is presented to show that malt product flours serve as antioxidants for edible oils. Five to thirty per cent of malt product flours when added to lard inhibited the accumulation of peroxides upon aeration or oxygenation. At room temperature flours from distillers, brewers, caramel malts and malt "sprouts" showed decreasing order of antioxidant activity. The antioxidant of malt sprouts could be concentrated by methanol extraction of sprouts which dissolved 10 to 15% of the source material. At 0.01% concentration, such extracts showed marked capability for inhibiting peroxide accumulation upon oxygenation of corn oil at 100° C. Preliminary trials suggest usefulness of the natural wholesome food malt as flours in stabilizing flavor of food products prepared in or with oil. Particularly advantageous to the use of malt as an antioxidant in food is that in addition to its inherent food values, by selection of malt type, flavoring, enzymatic or coloring values to the degree desired can be simultaneously achieved.

Acknowledgment

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LITERATURE CITED

1. Blank, E. W., Colt, E. W., Dollear, F. G., Laing, J. L., Fitelson, J., Long, C. P., Maroney, J. E., Milner, R. T., Parsons, L. B., Schuette, H. A., Sorenson, S. O., Tolman, L. M., Woeckel, F. C., Mehlenbacher, V. C. Report of the Committee on Analysis of Commercial Fats and Oils. *Ind. Eng. Chem. Anal. Ed.*, **27**, 336–340 (1945).
2. Chattopadhyay, H., and Banerjee, S. Effect of germination on the total tocopherol content of pulses and cereals. *Food Research*, 17, 402–3 (1952).
3. Hamilton, Elmer W. (to the Froedtert Corp.). Method of treating cooked food products. U. S. Patent 2,779,678 (Jan. 1957).
4. Schild, E., and Huyman, M. V. The influence of malt on the rH-poise of wort and beer. *Brewers Digest*, **24**, 71–75, 78 Technical (1949).
5. Stuffins, C. B., and Weatherall, H. Determination of the peroxide value of oils and fats. *Analyst*, **70**, 403 (1945).
6. Taüfel, K., and Köchling, J. Spoilage of fats. VIII. Influence of various substances before and after heating on stability of fats during storage. *Fette und Seifen*, **46**, 554–560 (1939).

Time-Temperature Tolerance of Frozen Foods.

XI. Retail Packs of Frozen Red Sour Pitted Cheeries

(Manuscript received July 8, 1957)

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PRINCIPLES AND OBJECTIVES of the project on time-temperature tolerance of frozen foods have been outlined and discussed by Van Arsdel in the first article of this series *(7)*. Results on several frozen fruits have been reported *(3, 4, 5)*. This paper deals with commercially packed frozen red sour pitted cherries.

MATERIALS AND METHODS

The cherries used in these experiments were processed in commercial plants with commercial equipment, and thus they represented frozen fruit that is normally distributed to the retail trade. Two "lots" were obtained from Oregon in 1950, two from Michigan in 1952, and 5 from Michigan in 1953. The cherries were soaked in water at 50 to 60° F. for 8 to 16 hours, pitted, sorted, washed, and weighed into containers in the ratio of 4 parts fruit to 1 part 60% sucrose sirup. Some samples were packed in paperboard metal-end containers and some in hermetically sealed tins. Some lots were frozen on trays in air-blast freezers operated at −10° to −40° F. and others were case-frozen in cold rooms with circulating air at −10° F. After freezing, the fruit was shipped to the laboratory in insulated containers with dry ice which maintained the product temperature below 0° F. at all times. On arrival the samples were placed in a constant temperature room maintained at −20° F. until the experimental temperature studies were begun. Each lot consisted of 120 to 500 retail packages and represented a typical commercial pack. The lots were selected to represent different commercial growing areas, handling practices, packaging materials, and freezing procedures.

Temperature schedules. Since the retail pack of frozen red sour pitted cherries is very limited and since results with other frozen fruits have shown that 20° F. can be used as an accelerated storage temperature, most of the work on cherries was done at a steady temperature of 20° F. Results obtained at this temperature are very similar to those which occur both below and above 20° F. A limited number of samples were stored at 0°, 10°, 25° F., and at a regularly fluctuating cycle from 0° to +20° to 0° F. every 24 hours. Some samples were exposed to a simulated distribution pattern in which the product was gradually warmed to +23° F. and cooled to 0° F. over a 14-day period, followed by additional storage at 20° F.

Sufficient samples from each lot were stored at the experimental temperatures to provide 4 to 6 packages for testing after each of 6 to 10 storage periods. At the end of the holding period samples were immediately cooled to −20° F. and maintained at this temperature until compared with their respective controls. The controls for each lot were maintained at a constant −20° F.

Organoleptic evaluation. Experimental and control samples were thawed in the draft of an electric fan for 2 hours, drained, prepared as pie filling and baked in a two-crust pie at 425° F. for 30 minutes. After cooling, the samples were presented to 3 judges who had extensive training and experience in judging quality factors in red sour pitted cherries. Three experimental samples and a hidden control were presented with a labeled control, and the judges were asked to rate the samples on a 7-to-1 scale for flavor and texture. The labeled control was rated 7.0 for each factor. Each sample was replicated 6 times, giving a total of 18 judgments. Color was evaluated separately by the same judges using the same number of samples, replications, and rating scale. The individual judge's ratings were very consistent for replicate samples, and there was excellent agreement among judges. Therefore the organoleptic results were expressed as panel averages for each quality factor and the difference between average ratings of the hidden controls and stored samples were plotted against storage time.

Physical and chemical measurements. Measurements were made on 4 to 6 packages, which were thawed and drained as described in the previous section. The number of visibly discolored cherries in each package was counted and expressed as a percentage of the total number. To measure the intensity of discoloration, the brown cherries were placed in matched glass dishes and reflectance measurements were made with a Hunter Color and Color Difference Meter. The instrument was standardized with a red tile (SKC-70) supplied by the National Bureau of Standards. The values used were Rd = 8.6, "a" = 64.4, and "b" = 17.3.

The distribution of color between cherries and sirup was determined by measuring the transmittancy of a water extract of the drained cherries and a diluted solution of the drained sirup at 515 mμ. The procedure was the same as for raspberries *(6)* except that the extraction was made with 0.3% oxalic acid solution to prevent color loss during blending. Rate of tannin oxidation was determined on samples prepared as slurries in a blender according to the procedure previously described *(2)*.

For firmness measurements the thawed cherries were filled level full in the sample box of a pea tenderometer and readings were taken on scale 2. A total of 4 readings was obtained from 2 packages of cherries.

Soluble solids were determined on the drained cherries and sirup by refractometer and expressed as per cent sucrose.

Drained weight was determined on samples thawed for 2 hours in circulating air at 70° F. and drained for 2 minutes on an 8-mesh screen.

RESULTS AND DISCUSSION

Enzymatic color changes during storage at 20° F. The most readily observable visible change in cherries stored at 20° F. was discoloration or browning of the fruit exposed to the headspace atmosphere. As with peaches the severity of this enzymatic discoloration was found to depend upon the degree of sirup coverage and storage temperature. Unlike peaches, however, there is an actual loss in the red anthocyanin pigment as well as an oxidation of other tannin-like phenolic compounds which are converted to brown-black substances. The relative rates of these two reactions under standardized conditions *(2)* are shown in Figure 1. It is apparent that the rates of tannin and color loss are very similar and that discoloration in red sour cherries occurs as a result of oxidation of the pigment as well as other tannin-like compounds.

The incidence of browning in hermetically sealed

[1] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

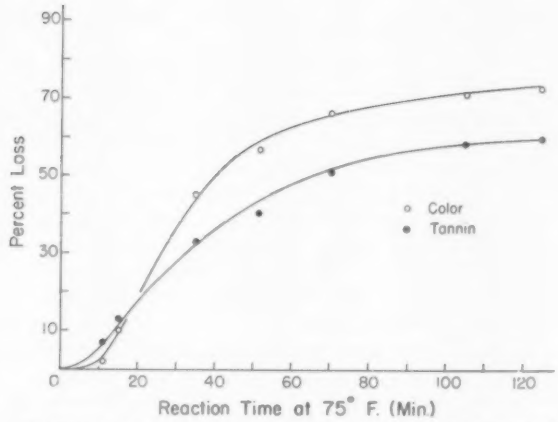

Figure 1. Color and tannin loss in a constantly aerated slurry of red sour pitted cherries.

tins held at 20° F. is shown in Figure 2. It is apparent that the cherries exposed to the headspace atmosphere became discolored rather rapidly and thereafter essentially no increase in number of brown cherries occurred. This relation would be expected in a hermetic container, since oxidation would be limited to the amount of oxygen sealed in the can and the degree of sirup coverage. There was no significant difference between lots obtained during 1952 and 1953. The maximum number of brown cherries (after 8 to 10 weeks of storage at 20°) varied between 15 and 18% of the total in each container.

Although counting the number of brown cherries gives an excellent indication of the incidence of browning, it does not necessarily provide information with regard to degree or intensity of discoloration. To arrive at a measure of the intensity, the exposed cherries in hermetic containers were placed in matched glass dishes and color was measured with a Hunter Color Difference Meter. The largest differences between control and stored samples were given by the "a" value, which is a measure of relative redness. Bright red unbrowned cherries gave an "a" value of about 35, while the dull brownish samples gave readings as low as 20 to 25. The change in "a" value at 20° F. is shown in Figure 3. It will be noted that for the first 3 to 4 weesk of storage the shape and slope of this curve are very similar to those for

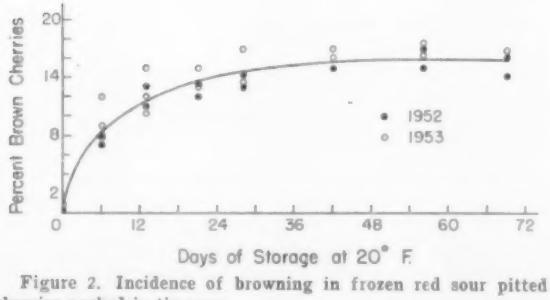

Figure 2. Incidence of browning in frozen red sour pitted cherries packed in tin cans.

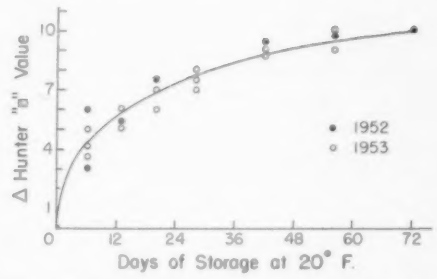

Figure 3. Degree of enzymatic discoloration as measured by changes in the Hunter "a" value.

browning (Figure 2), thus indicating a good correlation between the two measurements. After 4 weeks, however, the number of brown cherries remains essentially constant while the change in "a" value or relative redness continues to increase. Thus, even though the number of brown cherries remains fairly constant, the intensity or degree of browning in those cherries continues to increase.

Effect of container. As with frozen peaches, hermetic containers are much more protective than the metal-end, paperboard type. Figure 4 shows the increase in brown cherries with time at 20° F. for

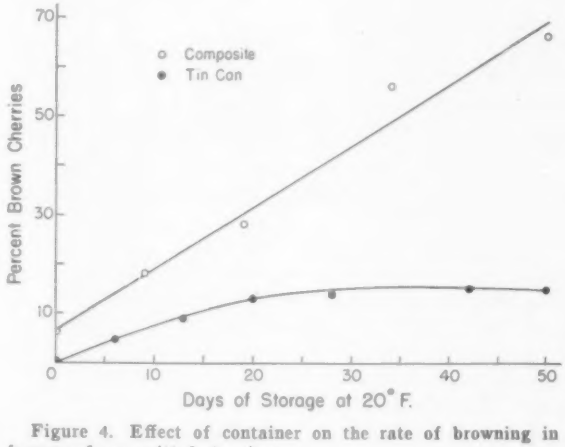

Figure 4. Effect of container on the rate of browning in frozen red sour pitted cherries.

both composite and hermetic containers. The superiority of the tin can is obvious for reasons already mentioned. The continual supply of air to the products due to the breathing action of non-hermetic containers causes extensive and severe browning in this type of container. It should be emphasized, however, that if the temperature is maintained at 0° F. or lower, differences due to container type are greatly minimized.

Color distribution. In addition to enzymatic color changes which have been discussed in the previous section, a transfer of color from cherry skins to surrounding sirup occurs at 10° F. and above. A typical example of color transfer at 20° F. is shown in Figure 5. This is the same type of change which was

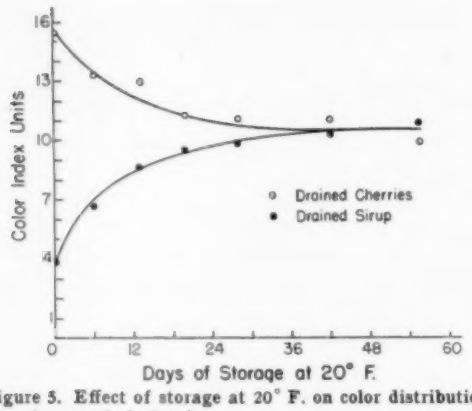

Figure 5. Effect of storage at 20° F. on color distribution in frozen sirup packed cherries.

found in frozen raspberries *(6)*. Expressed in terms of color ratio, or color index of fruit/color index of sirup, control samples varied from 3.5 to 4 and after 4 to 6 weeks at 20° F. dropped to values in the neighborhood of 1.0 or lower. After 3 to 4 weeks at 20° F. the submerged or unbrowned cherries were a light pale red, while the sirup had acquired a deep red color in contrast to the control samples in which the cherries were bright red and the sirup light pink. Obviously these changes can be used as a guide in evaluating temperature history.

Soluble solids distribution and drained weight. As pointed out in previous papers in this series, the soluble-solids distribution between fruit and sirup can serve as an excellent thawing indicator. Figure

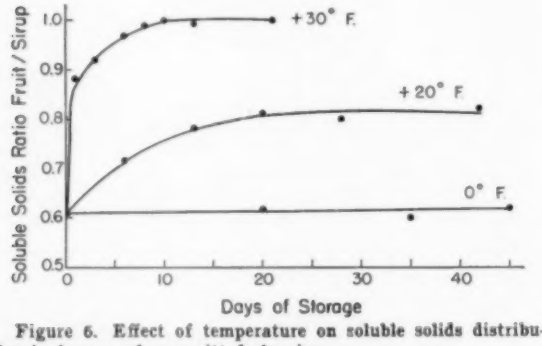

Figure 6. Effect of temperature on soluble solids distribution in frozen red sour pitted cherries.

6 shows that this is true for cherries as well as other fruits packed in sirup or sugar. A soluble solids ratio of 1.0 is attained only when the pack has been completely thawed long enough to allow equilibrium between fruit and sirup. For cherries stored at 30° F., this requires 8 to 10 days. However, it will be noted that a ratio of 0.9 is obtained in less than 5 days, indicating rapid exchange of solids and water. On the other hand, at 20° F. there is a very gradual increase in soluble-solids ratio until an apparent equilibrium value of approximately 0.8 is reached. Therefore, when values of 0.9 to 1.0 are found, it is virtually certain that the product has been completely thawed at some time.

No consistent trends of increasing or decreasing drained weights were observed at 10° to 30° F. in the 9 lots of commercial samples tested. However, a 5 to 10% decrease in drained weight was observed in samples which were slowly frozen in cases when compared to rapidly frozen fruit from the same lot. This was the only consistent difference observed between rapid and slow frozen fruits. The rapidly frozen samples reached 0° F. in approximately 6 hours while the slow frozen material required 36 to 48 hours to reach the same temperature.

Changes in firmness. One of the most interesting changes observed at 20° F. was a definite increase in firmness. This change was easily demonstrated by tenderometer measurements (Figure 7). Firmness

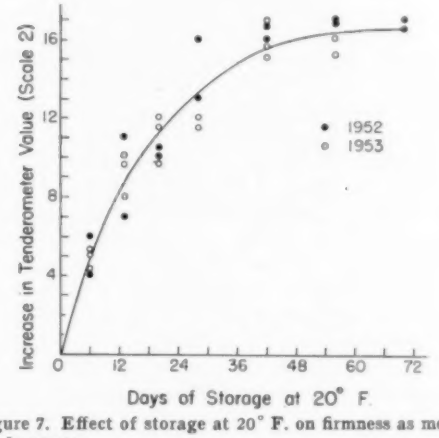

Figure 7. Effect of storage at 20° F. on firmness as measured by tenderometer.

increases rather rapidly during the first 4 to 5 weeks and then gradually levels off at a fairly constant value. Although there was some fluctuation in the tenderometer values for any given lot or time, the data indicate a very definite trend of increasing values with time and no significant differences between lots or seasons. The initial tenderometer values were in the range of 50 to 55 on scale 2, and increased to 65 to 70 after 8 to 10 weeks at 20° F. Gee and McCready have shown that these increases are associated with decreases in methoxyl content of the pectin in the cherries *(1)*.

Increases in firmness of drained cherries were found to correlate very well with organoleptic firmness scores of cherries baked in pie. As shown in Figure 8 there is a good linear relation between the two methods of assessing texture changes in frozen cherries which have been exposed to elevated temperatures. Thus the tenderometer can be used for the objective measurement of firmness in frozen thawed cherries, and these measurements can be useful in predicting relative firmness of cherries in baked pies.

Sensory evaluation of fruit as baked in pie. As

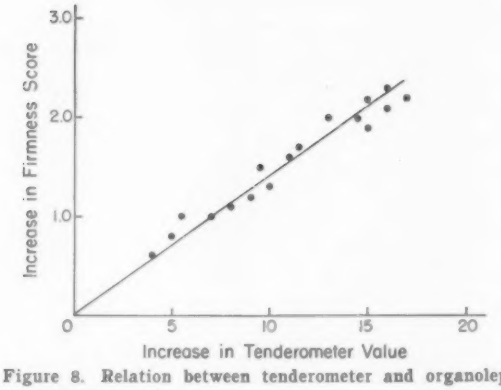

Figure 8. Relation between tenderometer and organoleptic firmness measurements.

Figure 9 indicates, the most readily detectable organoleptic change was an increase in firmness. This factor continued to increase rapidly during the first 4 weeks and thereafter appeared to level off in the same way that the tenderometer value leveled off after the initial rapid increase. When the instrument failed to register a change in firmness due to storage, the judges also were unable to detect significant texture changes. The flavor curve indicates that this quality factor closely paralleled firmness changes, but this relation may be largely due to the fact that it was impossible to eliminate the texture differences when flavor measurements were made. Even though judges were asked to disregard texture in their flavor evaluation there is little doubt that texture differences influenced flavor ratings. Although definite changes in texture and flavor occurred within 3 to 4 weeks at 20° F., it should be emphasized that these results were obtained with highly trained judges and do not necessarily indicate consumer reaction. Even though samples became detectably firmer and changed somewhat in flavor, the judges considered even the 6- and 8-week samples to be completely satisfactory in cherry pie.

Since the color data were obtained on portions of pie prior to tasting, texture changes did not influence the grading of this factor. The color curve indicates little or no difference between control and stored samples up to 6 to 8 weeks of storage at 20° F., and even then the observed differences were very small. Furthermore, if the stored samples were graded without benefit of a −20° F. control for comparison, the 6- to 8-week samples were considered entirely satisfactory from a color standpoint. Thus, it appears that cherries packed in hermetic containers will discolor to the extent of about 14 to 18% of the total count, but when the fruit is prepared and baked in pie, this amount of browning does not appear to detract seriously from the appearance of the baked fruit.

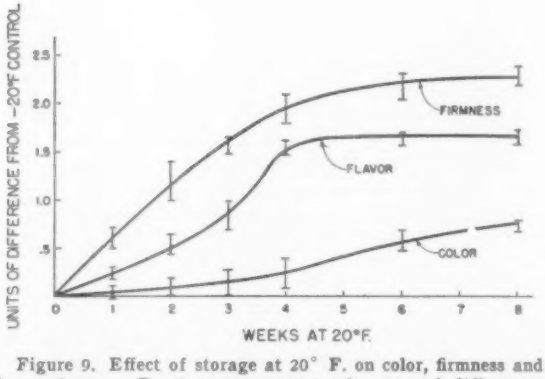

Figure 9. Effect of storage at 20° F. on color, firmness and flavor changes. Brackets represent total range of differences obtained with 7 "lots" of cherries. Units represent differences in average rating between control and stored samples.

Storage at other temperatures and conditions. Examination of a limited number of samples packed in tin cans and held at temperatures other than 20° F. indicated that little or no change took place at −20° F. during 5 years and at 0° F. during 2 years. At 10° F. changes approximately equivalent to those which occurred in 3 to 4 weeks at 20° F. developed in 5 to 6 months, and at 25° F. they were evident in 1 to 2 weeks.

Storage under a simulated distribution pattern in which the samples were gradually warmed to 23° and cooled to 0° F. over a period of 14 days, followed by additional storage at 20° F. for various periods, indicated that deteriorative changes under these conditions are additive. Changes which occurred during the simulated transportation cycle were equivalent to approximately 1 week at 20°, and additional storage at 20° resulted in further changes which were approximately equal to those that occurred at a steady 20° F. without prior exposure to the simulated transportation pattern. These results are in agreement with those obtained with all other frozen fruits studied to date.

Storage at a regularly fluctuating cycle from 0° to +20° to 0° F. every 24 hours gave results which were very similar to those obtained at a steady temperature of 10° F. for periods up to 6 weeks. Therefore, it appears that as in other frozen fruits, fluctuation *per se* does not cause flavor or color changes which would not be expected at equivalent steady temperatures.

SUMMARY

Nine lots of commercially packed frozen red sour pitted cherries have been evaluated over a period of 3 seasons. A small highly trained panel found definite texture and flavor differences in all lots after 3 to 4 weeks at 20° F. Color differences in baked pie did not change appreciably until the cherries had been held 6 to 8 weeks at this temperature.

The most readily observable change in the thawed unbaked cherries stored at 20° F. was browning of fruit exposed to headspace atmosphere. Hermetically sealed tins were superior to composite cartons from the standpoint of preventing enzymatic discoloration at elevated temperatures. The number of brown cherries and degree of browning as measured by the Hunter Color Difference Meter provided a means of estimating temperature history. Color distribution

between cherries and surrounding sirup was also useful in determining time-temperature exposure.

Soluble solids distribution was found especially useful as a thawing indicator.

The most readily detectable change in pie-baked cherries was an increase in firmness with storage time. A linear relation was found between organoleptic assessment of firmness changes and tenderometer measurements.

Storage under fluctuating temperatures and simulated distribution patterns indicated that changes which occurred under these variable temperature conditions were similar to those which occurred at an equivalent steady temperature.

Acknowledgment

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LITERATURE CITED

1. Gee, Mildred, and McReady, R. M. Changes in frozen Montmorency cherries. *Food Research*, 22, 300 (1957).
2. Guadagni, D. G., and Nimmo, C. C. Effect of growing area on tannin and its relation to astringency in frozen Elberta peaches. *Food Technol.*, 8, 59 (1953).
3. Guadagni, D. G., Nimmo, C. C., and Jansen, E. F. Time temperature tolerance of frozen foods. II. Retail packages of frozen peaches. *Food Technol.*, 11, 33 (1957).
4. Guadagni, D. G., Nimmo, C. C., and Jansen, E. F. Time temperature tolerance of frozen foods. V. Commercially packed retail size frozen strawberries. *Food Technol.*, 11, 389 (1957).
5. Guadagni, D. G., Nimmo, C. C., and Jansen, E. F. Time temperature tolerance of frozen foods. X. Retail packs of frozen raspberries. *Food Technol.*, 11, 633 (1957).
6. Guadagni, D. G., and Nimmo, C. C. Time temperature tolerance of frozen foods. IX. Effect of time and temperature on color distribution in retail packs of frozen raspberries. *Food Technol.*, 11, 604 (1957).
7. Van Arsdel, W. B. The time temperature tolerance of frozen foods. I. Introduction—The problem and the attack. *Food Technol.*, 11, 28 (1957).

Time-Temperature Tolerance of Frozen Foods

XII. Turkey Dinners and Turkey Pies[a]

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Investigation of the flavor stability of frozen turkey dinners and turkey pies was undertaken to develop comprehensive and reliable information on the storage stability of these relatively new products, which are of greatly increased commercial interest. Turkey rather than chicken products were selected for the initial studies because turkey is less stable than chicken under all conditions thus far studied *(8)*. Therefore, conditions found to be satisfactory for preventing deteriorative changes in the flavor of the turkey products, would be satisfactory, presumably, for chicken products of the same type. To determine whether or not comparable stability was achieved after different processing conditions and to permit incorporation of antioxidants as a means of retarding expected deteriorative changes, commercially prepared products were supplemented by studies of laboratory-prepared products.

Storage temperatures included constant temperatures ranging from −30° F. (−34.4° C.) to 20° F. (−6.7° C.) and temperatures fluctuating uniformly from −10° to 10° F. (−23.3° to 12.2° C.) and from 0° to 20° F. (−17.8° to −6.7° C.) in a 24-hour sine wave cycle. Limited studies were also made of the effect of storage at 10° F., either preceded or followed by storage at 20° F.

METHODS

Laboratory-prepared turkey dinners consisting of 40.8% bread dressing, 14.8% dark meat, 22.2% white meat, and 22.2% gravy were packaged in aluminum pie plates (diameter 9 inches, depth ⅞ inch) with a heavy aluminum foil covering. The following procedure was used in the preparation of the plates:

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 12–16, 1957.

[b] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

Three lots of frozen, ready-to-cook, whole (16–20 lbs.) turkeys were obtained from two commercial sources. They were held at −20° or −30° F. until prepared as dinners. Not more than 2 months elapsed between killing the birds and preparing the dinners, except for controls that were prepared at the end of the various storage periods. The frozen turkeys were halved with the electric saw and the halves were randomized among the treatments in each lot. The halves were thawed approximately 17 hours at room temperature (70° F.), and then simmered in covered stainless-steel kettles containing one liter of water per 1800 g. of bird. For treatments receiving antioxidant, a formulated antioxidant composed of 20% butylated hydroxyanisole, 6% propyl gallate, 4% citric acid, and 70% propylene glycol was added at a concentration of 0.005% of the uncooked weight of the turkey halves to the water in which the birds were simmered. Cooking time was approximately 2 hours, or until the internal temperature of the breast muscle reached 190° F. The turkeys were chilled at 35° F. for 1 hour; then the meat was separated from the bone and sliced 0.15 inch thick on a meat slicer.

The formula for the dressing was as follows: a commercial bread stuffing mix 30.6%; butter, grade AA 15.9%; defatted turkey broth, 44.6%; fresh onion, 8.9%.

The gravy consisted of 6.0% fat, 5.6% flour (2/3 waxy rice, 1/3 wheat), 87.31% defatted turkey broth, 0.9% salt, 0.18% pepper. Hydrogenated vegetable oil was the fat used in all laboratory preparations except those designed to test the value of an antioxidant addition. In the latter, turkey fat was also used. .. the treatments in which antioxidant was added to the fat used in the gravy, the amount added was 0.1% of the weight of fat used in the gravy. The dressing was placed in the bottom of the plate. On top of this were the dark meat slices, then the light meat slices, and finally the gravy.

Plates were frozen in a −20° F. air blast freezer for 24 hours, and then transferred to −30° F. until all dinners in each lot were prepared. They were then stored at the required storage temperatures.

Commercially prepared turkey dinners and pies were removed from the shipping cartons and stored with air space between the individual packages on racks in the storage rooms. Dinners were in compartmented aluminum trays with an aluminum cover, boxed, and overwrapped. Pies were in aluminum pie plates, boxed, and overwrapped.

The laboratory-prepared dinners were reheated from the frozen state in a rotary oven for 60 minutes at 450° F. and the commercially prepared dinners and pies were reheated from the frozen state according to the directions on the package.

Components of the turkey dinners tested for flavor changes were sliced light and dark meat, dressing, and gravy. All components of the turkey pies were tested, including crust, diced turkey meat, peas, and sauce. Composites rather than individual components were tested by the judges.

At each storage period from 2 to 4 samples were compared at one time by a panel of 6 trained judges who ranked the samples for off flavors and checked for any stale, rancid, or other off-flavor. Results were analyzed by the method of analysis of variance with the usual reduction in number of degrees of freedom required for ranked data. Least significant difference was determined by the method of Scheffé *(11)*. There were 4 replications of all comparisons at each storage period. Storage periods ranged from 0.5 to 15 months (Table 1). The samples were judged for flavor under sodium lights to mask any possible differences in appearance.

Peroxide values were determined on the meat and dressing separately at the early storage periods for both the laboratory- and commercially-prepared dinners. Since the values were consistently lower on the dressing than on the meat, at the later storage periods determinations were made on the meat only. Peroxide values were determined on a composite of the meat and sauce of the turkey pies. In the laboratory preparation of the dinners, peroxide values were also determined on the turkey fat extracted from the broth immediately after cooking the turkeys. Peroxide values were determined by the method described by Pool *et al. (9)*.

Reduced ascorbic acid and chlorophyll-pheophytin conversion determinations were made on the peas in a limited number of commercially prepared turkey dinners by the procedures used by Dietrich *et al. (1)*.

RESULTS

1. Dinners and pies stored at constant temperatures. Flavor changes occurring during frozen storage of the turkey dinners and turkey pies were less pronounced than had been expected on the basis of previous studies of frozen cooked turkey *(4, 7)*. The first change detected in these products was generally a

TABLE 1

Effect of frozen storage on off-flavor development of turkey dinners and pies

Samples ranked for degree of off-flavor ° F.	Dinners or pies (D or P)	Commercial or laboratory preparation (C or L)	Statistical significance of differences at storage times (months) tested					
			0.5-1	1.5-2	3-4	6	9	12
20° vs. −30°	D	C	=	** **	**			
20° vs. 0°	D	C	—	**	**			
20° vs. 0°	P	C	—	—	**			
20° vs. 10°	D, P	C	=	=	=			
10° vs. −30° [1]	D	L			—	*	**	**
10° vs. −30°	D	C			**			
10° vs. −30°	D	L			—	—	—	—
10° vs. −10°	D, P	C		=	=	=		=
10° vs. −10°	D	L		—	—	—		—
10° vs. 0°	D, P	C	=	=	=	=	=	=
10° vs. 0°	D	L		—	=	* =	—	=
0° vs. −30° [1]	D	L			—	—	**	—
0° vs. −30°	D	L			—	—	—	—
0° vs. −10°	D, P	C		=	=	=		=
0° vs. −10°	D	L		—	—	—		—
−30° vs. −30° [1]	D	L			—	=	*	** —

[1] Stored uncooked, cooked at end of storage periods.
— Difference not statistically significant.
* Difference statistically significant ($P = 0.05$).
** Difference statistically significant ($P = 0.01$).
Multiple entries for a single storage condition indicate tests on more than one lot.

loss of the typical "fresh" turkey flavor, followed by the development of a stale flavor and, under some conditions, a rancid flavor. Occasionally, and without any relation to storage temperature, other off flavors described as "painty" and "fishy" were encountered. There was no apparent difference in rate of off flavor development in commercial and laboratory preparations held under comparable storage conditions. The only samples distinguished with any consistency by the panel were those held under the extreme storage conditions—dinners and pies held at 20° F. and dinners prepared at the end of the various storage periods from turkeys held uncooked at −30° F. (Table 1). The products held at 20° F. had a stale or rancid flavor that was detected in the dinners after 1.5 to 2 months of storage and in the pies after 3 to 4 months of storage. The dinners prepared at the end of each storage period from uncooked turkeys held at −30° F. had a typical fresh turkey flavor that distinguished them from the cooked dinners stored at −30° F. and above for 6 to 12 months. Although in a few instances dinners stored at 10° F. were judged to have significantly more off flavor than those stored at lower temperatures, in general, products held in the temperature range −10° to 10° F. were not consistently distinguished from each other after storage periods ranging from 1 to 12 months. The judges commented occasionally on a stale or rancid flavor in products stored at all of the temperatures. Comments were most frequent on products stored 6 months or longer.

Peroxide values of the meat used in turkey dinners prepared commercially or in the laboratory generally increased with increasing storage time and temperature. Peroxide values of dinners stored at −30° F. remained low (10 or less) during 12 months' storage, and those of dinners stored at 20° F. became high (35 to 80) after 6 months' storage. Dinners stored at −10°, 0° and 10° F. had peroxide values ranging from 8 to 15 at storage periods of 4 months or less and from 11 to 45 at storage periods from 6 to 12 months. There was no consistent difference in peroxide values attributable to storage temperature in the −10° to 10° F. range. Values were not higher after 12 months' than after 6 months' storage.

In many cases peroxide values did not correlate well with detection of flavor changes by the judges. Peroxide values, for example, remained low (9 to 12) during 3 months' storage of the dinners at 20° F., but the panel detected flavor changes, including rancidity development, after 1½ months. Similarly, peroxide values of the dinners held at −30° F. for 6 to 12 months and those of the dinners prepared at the end of the storage periods from frozen turkeys held at −30° F. were essentially the same, ranging from 6 to 11. Yet the panel consistently detected less off flavor in the dinners prepared at the end of the storage periods. Peroxide values of the turkey pies stored for 9 months at 20° F. remained low (12 or less), but the judges commented on the rancid off flavor after only 4 months' storage. Thus, without additional information concerning storage conditions, peroxide values are of little value in these products in determining presence of a rancid flavor.

Considerable mold growth occurred on the crusts of turkey pies held for 9 months at 20° F. No visible growth occurred on pies from the same lot held for 6 months at 20° F.

Mr. W. C. Dietrich of the Vegetable Processing Section of this laboratory determined ascorbic acid and the chlorophyll to pheophytin conversion in the peas in commercially prepared dinners. There was a 40 to 45% decrease in reduced ascorbic acid in control (−30° F.) samples due to heating of the dinners. (Heating sufficient to bring the dinners to serving temperature is adequate to cook the peas.) Storage of dinners at 10° and 20° F. before heating increased the loss. One month of storage at 20° F. followed by heating resulted in a total loss of 75% of ascorbic acid, and 3 months' storage at 20° F. followed by heating resulted in a loss of 95% of ascorbic acid. Three months' storage at 10° F. followed by heating resulted in a 55% loss. These losses are in agreement with losses generally found in peas that are cooked following comparable frozen storage.

Considerable change in color occurred during heating of the peas as measured by the per cent conversion of chlorophyll to pheophytin. Heating caused a 5-fold average increase in pheophytin in the control samples, from 6% to a range of 25 to 34%. This large variation in conversion on heating overshadows smaller changes of 2 to 5% caused by 1 to 2 months' storage at 20° F.

II. Dinners and pies stored at fluctuating or alternating temperatures. Storage of commercially prepared turkey dinners and pies and laboratory-prepared turkey dinners at fluctuating temperatures was no more damaging to flavor of these products than storage at the constant mean temperature. This finding is in agreement with results of similar flavor comparisons on uncooked frozen foods *(2, 3, 5, 6, 10)*.

Products held at temperatures fluctuating from 0° to 20° F. in a 24-hour sine wave cycle were compared with products from the same lots held at a constant temperature of 10° F., and products held at temperatures fluctuating from −10° to 10° F. were compared with products held at a constant temperature of 0° F. No significant difference in flavor was found in any of the comparisons after storage periods of 1, 2, 3, 4, 6, 9 and 12 months. Peroxide values of the products held at fluctuating and at constant temperatures were essentially the same for storage periods of 6 months or less. Peroxide values of the products at the fluctuating temperatures tended to be higher than those held at the constant temperatures after storage for 9 and 12 months. However, sufficient tests were not made to determine whether this difference was real or merely the variation usually associated with this determination.

Sequential storage of commercially prepared turkey dinners likewise caused no important flavor effect. Dinners stored at 20° F. for ½, 1 and 1½ months followed by storage at 10° F. for 3 months were compared at the end of the storage period with dinners stored at 10° F. for 3 months followed by storage at 20° F. for ½, 1, and 1½ months. No flavor difference was found between the samples for any of the 3 comparisons (½ mo. at 20° + 3 mo. at 10° vs. 3 mo. at 10° + ½ mo. at 20° etc.). There were no differences in peroxide values for any of the comparisons. Under these rather limited conditions, the higher temperature at the beginning of the storage period was, therefore, no more detrimental to the product than the higher temperature at the end of the storage period.

III. Dinners prepared with antioxidants. Experiments conducted with laboratory-prepared turkey dinners showed that antioxidant addition was not particularly effective in preventing rancidity development at temperatures of 10° F. and 0° F. for periods ranging from 2 months to 1 year. Two kinds of fat were used in the gravy, hydrogenated vegetable oil and turkey fat. A comparison of peroxide values of the dark meat and rancid flavor development (Table 2) showed that peroxide values and rancidity comments tended to be lower in the samples containing antioxidants. However, under none of these conditions did the judges find a statistically significant flavor difference between the dinners prepared with and those prepared without an antioxidant. Thus, the antioxidant in the sauce was not sufficient to prevent flavor changes in the

TABLE 2

Effect of antioxidant addition on peroxide values and rancid flavor development in meat in frozen turkey dinners

Type of fat in gravy	Antioxidant	Storage temperature (° F.)					
		0°			10°		
		Storage time (mo.)			Storage time (mo.)		
		6	9	12	2	4	6
I. Peroxide values[1]							
Hydrogenated vegetable oil	added	....	16	12	10	12	47
	none	....	23	25	10	12	33
Turkey fat	added	....	....	12	12	9	....
	none	....	....	20	20	17	....
II. Rancidity comments (as % of total possible comments)							
Hydrogenated vegetable oil	added	....	4	17	4	21	17
	none	....	8	38	8	8	25
Turkey fat	added	4	....	42	4	4	....
	none	4	....	38	17	17	....

[1] Value determined on fat extracted from dark meat.

dark meat in this type of product. It is possible that antioxidants would be more effective under more adverse holding conditions, but such conditions are not to be recommended.

DISCUSSION

A probable explanation for the somewhat unexpected stability of these products at a storage temperature of 10° F. can be found by comparison with a previous study on laboratory-prepared creamed turkey *(4)*. In the creamed turkey, as in the dinners and pies, the rendered turkey fat was not used in the sauce or gravy because of its recognized instability. The meat was covered with a sauce, effectively excluding air from most of the sample. In hermetically sealed cans no flavor difference was found between the creamed turkey samples stored at 10° F. and those at −30° F. for periods as long as a year. In a more permeable packaging material, consisting of a carton, MSAT cellophane liner and laminated waxed-paper overwrap, a somewhat stale off flavor was detected after 4 months' storage at 10° F. and rancidity after 12 months. Apparently, therefore, since the turkey dinners and pies have a reasonably solid pack and are well protected from the air by the type of container used, they are reasonably stable even at 10° F. Occasional rancidity and increase in peroxide values in the dark meat would be expected in portions of the sample not adequately protected from oxidative changes.

No stability problems are encountered by the inclusion of vegetables in products such as turkey pies. It has been shown previously *(4)* that although cooked peas stored in a loose pack develop off flavor in storage at a faster rate than do blanched peas, when stored in a solid pack surrounded by a sauce or gravy they have essentially the same stability. Blanched peas are generally used in these products as reheating time is adequate to cook them, but vegetables requiring a longer cook would require cooking before freezing.

SUMMARY AND CONCLUSIONS

Turkey dinners and turkey pies, both laboratory and commercial preparations, were evaluated for flavor and other changes after storage at temperatures ranging from −30° to 20° F. Stale and rancid flavors developed in from 1½ to 3 months in samples held at 20° F., and significant loss of ascorbic acid in peas contained in the turkey dinners occurred in 3 months at 20° F. Mild stale flavors and occasional rancidity developed in these products after 6 to 12 months at 10° F. and below. Thus, these products are 3 to 6 times as stable at 10° as at 20° F. Under the conditions used, antioxidant addition did not cause sufficient improvement in flavor stability of the meat to warrant its inclusion in dinners stored for a year at 0° F. or 6 months at 10° F.

Temperatures fluctuating from 0° to 20° F. and from −10° to 10° F. did not cause flavor changes differing significantly from those held at the mean temperatures of 10° and 0° F.

Peroxide values generally increased with increasing storage time and temperature, but did not show sufficient correlation with rancid flavor development to be useful for predictive purposes.

Although samples held for a year at 10° F. or lower showed flavor changes only part of the time, for *optimum* retention of the desirable qualities of turkey dinners and pies, exposure to 20° F. should be avoided and storage at 10° F. or lower should be limited to 6 months or less.

Acknowledgment

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LITERATURE CITED

1. Dietrich, W. C., Lindquist, F. E., Miers, J. C., Bohart, G. S., Neumann, H. J., and Talburt, W. F. The time-temperature tolerance of frozen foods. IV. Objective tests to measure adverse changes in frozen vegetables. *Food Technol.*, 11, 109 (1957).
2. Gortner, W. A., Fenton, F., Volz, F. E., and Gleim, E. Effect of fluctuating storage temperatures on quality of frozen foods. *Ind. Eng. Chem.*, 40, 1423 (1948).
3. Guadagni, D. G., Nimmo, C. C., and Jansen, E. F. The time-temperature tolerance of frozen foods. II. Retail packages of frozen peaches. *Food Technol.*, 11, 33 (1957).
4. Hanson, H. L., Winegarden, H. M., Horton, M. B., and Lineweaver, H. Preparation and storage of frozen cooked poultry and vegetables. *Food Technol.*, 4, 430 (1950).
5. Hustrulid, A., Winter, J. D., and Noble, I. How do fluctuating storage temperatures affect frozen foods? *Ref. Eng.*, 57, 38 (1949).
6. Klose, A. A., Pool, M. F., and Lineweaver, H. Effect of fluctuating temperatures on frozen turkeys. *Food Technol.*, 9, 372 (1955).
7. Lineweaver, H., Anderson, J. H., and Hanson, H. L. Effect of antioxidants on rancidity development in frozen creamed turkey. *Food Technol.*, 6, 1 (1952).
8. Mecchi, E. P., Pool, M. F., Behman, G. A., Hamachi, M., and Klose, A. A. The role of tocopherol content in the comparative stability of chicken and turkey fat. *Poultry Science*, 35, 1238 (1956).
9. Pool, M. F., Hanson, H. L., and Klose, A. A. Effect of prefreezing hold time and antioxidant spray on storage stability of frozen eviscerated turkeys. *Poultry Science*, 29, 347 (1950).
10. Pottinger, S. R. Effect of fluctuating storage temperatures on quality of frozen fish fillets. Fish and Wildlife Service, U. S. Dept. of Interior, *Commercial Fisheries Review*, 13, No. 2, 19 (Feb. 1951).
11. Scheffé, H. A method for judging all contrasts in the analysis of variance. *Biometrika*, 40, 87 (1953).

Predicting the Color of Canned Sockeye Salmon from the Color of the Raw Flesh

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As is the case with many other food products, the color of canned salmon is a very important quality factor *(5)*. Most salmon flesh contains red carotenoid pigments *(2)* which lend an attractive color to the canned products. In this country, Government requirements for color must be met only for canned spring salmon *(Oncorhynchus tschawytscha) (4)*. Specifications for red, pink, and white canned spring salmon have been defined in terms of Lovibond-Schofield red units *(14)*. There are no official color standards for the other four species of canned salmon. However, the salmon canneries generally color grade all products each to their own standards. Unfortunately, the color grade must be predicted prior to canning. This has presented a problem which industry has attempted to minimize by canning separately fish from areas known to have lower color quality and also by visual grading of the raw fish. Such visual grading is done without material standards for comparison. Although the Lovibond-Schofield instrument is suitable for inspection purposes, it is not used for the commercial grading of salmon. The color of the various grades of canned salmon have not been sufficiently uniform, indicating that more accurate methods of specification and prediction of the color are needed. Precise color specifications would be useful both for grading purposes and for the establishment of regulatory standards.

For the present study, an accurate objective method of color measurement was necessary. Charnley *(5)* and Charnley and Bolton *(6)* made color measurements of canned salmon using a modified Lovibond Tintometer to study the relationship between red and yellow color units. In recent years photoelectric instruments have been utilized for the measurement of the color of various food products. The Hunter Color-Difference Meter has had successful application in color studies on tomatoes *(3, 16)*, tomato juice *(11, 12)* and strawberries *(15)*. The Gardner Automatic Color-Difference Meter *(1)*, which is an automatic model of the Hunter Color-Difference Meter, was used in this investigation.

Of the 5 species of Pacific salmon, sockeye *(Oncorhynchus nerka)* was selected for study because it has the greatest commercial value in this area. This project was undertaken to determine a basis for indicating the visual color preference for canned sockeye salmon and to ascertain the feasibility of predicting the color of canned sockeye salmon from the color of the raw flesh. Other aspects included in this study were: (a) a comparison between color measurements of raw and canned salmon made with the Beckman DU spectrophotometer, the Lovibond-Schofield Tintometer, and the Gardner Color-Difference Meter; (b) the correlation between the oil content and color of canned sockeye salmon; (c) the effect of increased temperature and time of processing on the color of the canned product; (d) the effect of *post-mortem* storage on the color of canned salmon.

PROCEDURE AND MATERIALS

Spectrophotometric measurements. Directional reflectance measurements were made using a Model DU Beckman Spectrophotometer equipped with a reflectance attachment and a "photomultiplier" tube. A white vitrolite block calibrated against 2 different $MgCO_3$ blocks was used as a reference standard. Measurements were taken at 10 mμ intervals from 400 to 750 mμ and the slit width was never allowed to exceed 0.15 mm. The I.C.I. (International Commission on Illumination) tristimulus values for illuminant C were calculated by the summation method *(10)*. The large-scale chromaticity charts of Hardy *(8)* were used to obtain the dominant wavelength and per cent excitation purity.

Color-Difference Meter measurements. The Gardner Automatic Color-Difference Meter was used for these measurements. This instrument is the same as the Hunter Color-Difference Meter, except that its measuring circuit has been changed to include motor-driven potentiometers for speed and ease of operation. The *Rd* scale and large area illumination without a cover plate were used throughout. The instrument was adjusted to give the reading of the reference standard before each sample was measured. For the raw samples, the average of triplicate measurements of *Rd*, *a* and *b* were taken, the sample being turned twice after the initial measurement. Single readings of *Rd*, *a* and *b* were sufficient for the canned samples because of the excellent reproducibility of these measurements. The reference standards were 2 colored porcelain-on-steel tiles manufactured especially for this study and calibrated using the Beckman spectrophotometer, which was checked with standards supplied by the Gardner Company. The *Rd*, *a* and *b* values were calculated from the tristimulus values using the appropriate equations *(9)*. The reference tile used with the raw samples had *Rd*, *a* and *b* readings of 8.73, 33.8 and 20.7 respectively, while that used with canned samples had values of 35.9, 15.4 and 24.1, respectively. The reflectance curves of these 2 tiles were similar to those of raw and canned sockeye salmon as shown in Figure 1.

The Lovibond-Schofield Tintometer. This is a visual subtractive colorimeter using Lovibond glass filters like the Lovibond Tintometer but having an auxiliary device for controlling the luminance of the comparison field. Color measurements can thus be made using only 2 of the 3 series of color slides. Conversion graphs are provided so that the readings can be converted to the I.C.I. system. A $MgCO_3$ block was used as a reference standard and a liquid filter served to provide illuminant C. The average of two measurements made on each sample was used.

Preparation of samples. A half-lb. steak was cut from the section just forward of the dorsal fin of each raw fish. For the Color-Difference Meter and Lovibond-Schofield measurements, a small bone-free and skin-free sample was placed in a dish 3 inches in diameter and one-half inch in depth and was smoothed

with a blade. For the spectrophotometric measurements the sample was reduced in size to fit a one and one-half inch diameter dish. After taking the color measurements, the sample together with the steak from which it was cut, was placed in a half-lb. salmon tin, vacuum closed and processed at 116° C. for 90 minutes. To make color measurements of the processed fish, the skin, bones and curd were removed and the remaining flesh and liquor were thoroughly mixed with a spoon. Samples were then placed in the dishes, smoothed with a blade and the color measurements taken.

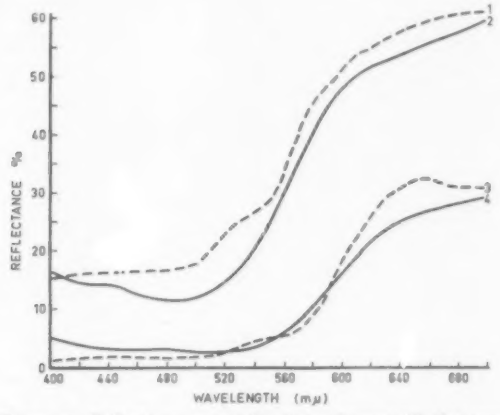

Figure 1. Reflectance curves for (1) reference tile for canned salmon measurements; (2) canned salmon; (3) reference tile for raw salmon measurements; (4) raw salmon.

Determination of oil content. The oil content of the canned samples was determined by a method developed especially for this purpose *(13)*. This method, which was more rapid than standard procedures, was employed because of the large number of samples (416) analyzed. To determine the oil content by this procedure the sample of canned salmon is minced in a Waring blender. Ten grams of the sample are weighed into a 100-ml. volumetric flask. Forty ml. of acetone and some boiling chips are added and the mixture is refluxed for one hour. Thirty-five ml. of methylene chloride are then added and the refluxing is continued for an additional 30 minutes. The solution is then cooled to 25° C., made up to volume with methylene chloride and shaken. It is filtered through glass wool and 50 ml. of the filtrate is measured into a 100-ml. tared beaker. The solvent is evaporated on a steam bath and later in a vacuum oven at 100° C. for 1 hour. After cooling, the beaker is weighed and the per cent oil is calculated from the formula, % oil = (wt. of oil/wt. of sample) × 186. This method has been compared with established procedures and the results will be published elsewhere.

RESULTS AND DISCUSSION

Comparison of 3 color-measuring instruments. Seven samples of both the raw and processed fish were subjected to color measurement using the Beckman DU spectrophotometer, the Lovibond-Schofield Tintometer and the Gardner Color-Difference Meter. These measurements were converted to I.C.I. dominant wavelength and per cent excitation purity and are recorded in Table 1. The 3 instruments did not give identical results. Such discrepancies have been observed by other investigators working with different products *(7, 11, 15)*. Agreement between the spectrophotometer and Color-Difference Meter was better than between the spectrophotometer and Lovibond-Schofield Tintometer. Because of the long period of time required for the spectrophotometric measurements, considerable darkening of the sample surface occurred before the measurements were completed and may account for some of the discrepancies. Agreement between instruments was better for processed samples than for raw samples. This is not surprising because the reproducibility of measurements with a given instrument was found to be much better for the processed samples, and may be attributed to the fact that the raw samples were not so uniform in color, had an irregular surface texture and a slight translucency. The Color-Difference Meter has several advantages over the other two instruments for these measurements. Because of the nature of the raw samples, more accurate results can be obtained with an instrument viewing a larger sample area as does the Color Difference Meter. In addition, this instrument is much more convenient and more rapid than either of the other two.

Color measurements of raw and processed sockeye salmon. Typical reflectance spectra of a sample before and after processing are shown in Figure 1. Processing increased the brightness throughout the entire visible region, particularly above 560 mμ.

TABLE 1

Comparison of instruments for color measurement

Sample No.	Spectrophotometer			Color-Difference Meter			Lovibond Schofield		
	Y, %	Dominant wavelength mμ	Purity %	Y, %	Dominant wavelength mμ	Purity %	Y, %	Dominant wavelength mμ	Purity %
Raw Sockeye Salmon									
1	8.39	603.6	56.0	9.0	602.3	71.2	11.5	604.7	70.5
2	9.97	598.2	58.3	12.2	598.9	66.5	11.8	603.0	66.0
3	10.6	599.0	57.5	11.5	600.0	69.7	14.5	599.7	70.5
4	10.0	598.7	57.5	11.5	600.1	68.0	12.3	601.7	70.4
5	12.1	595.6	54.0	14.0	596.8	64.2	16.6	599.4	59.1
6	9.96	600.0	58.0	12.1	600.1	68.0	12.9	600.5	73.2
7	10.7	600.0	63.3	13.2	600.2	68.4	14.5	602.0	67.4
Processed Sockeye Salmon									
1	30.3	590.0	49.4	34.9	588.9	50.3	48.0	590.1	48.3
2	35.9	588.6	43.6	38.6	587.4	43.6	41.7	589.7	44.3
3	35.2	589.8	48.3	39.6	589.1	49.3	40.7	590.4	47.3
4	33.6	589.3	50.0	37.8	589.0	48.1	40.7	590.8	46.2
5	36.2	587.6	43.0	40.8	586.3	41.5	43.7	589.2	38.7
6	32.2	589.5	50.2	36.5	588.5	47.9	33.1	590.0	45.6
7	30.6	590.0	48.0	33.9	588.8	48.2	33.9	591.2	44.6

Color-Difference Meter data were obtained on samples from 416 individual freshly-caught sockeye salmon before and after canning. The fish were caught in 8 different areas and at various times during the 1956 season. The *Rd*, *a* and *b* readings for 60 of these samples were selected to contain approximately the whole range of colors, were converted to I.C.I. trichromatic values and then to dominant wavelength and per cent excitation purity. Extensive changes occurred in each of the 3 color dimensions during the cooking process (Table 2). The samples became much lighter while the hue was shifted from red to orange-red and orange and the purity decreased.

Color measurements of canned salmon. The *a* readings ranged from 7.1 to 29.8 and had an average value of 19.9 while the *b* readings varied from 19.5 to 26.9. There was excellent correlation between the *a*/*b* ratio and the dominant wavelength. However, there was very good agreement between the dominant wavelength and the *a* value alone, the linear correlation coefficient being 0.991 for the 60 samples previously mentioned. In addition, the *a* value was found to correlate well with purity and lightness, the correlation coefficients being 0.943 and −0.834, respectively. This meant that with an increase in *a* value, there was an increase in dominant wavelength, purity and darkness. During the course of these measurements it became evident that the *a* readings were a good measure of visual color preference. A panel of qualified representatives from the salmon canning industry and from the Canadian Government Canned Fish Inspection Laboratory were consulted to make visual color judgments of approximately 100 samples of canned sockeye salmon. Their evaluations showed that the higher the *a* value the more preferable was the color of the product. In collaboration with this panel it was concluded that there should be 3 commercial color grades of sockeye salmon with specifications defined in terms of *a* values as follows: grade 1, the best grade, shoul have *a* values greater than 20; grade 2 should have *a* values not greater than 20 and not less than 14.5, while grade 3 should have *a* values less than 14.5. On the basis of these specifications, Table 3 lists the percentage of fish that were grades 1, 2 and 3 when canned from each of the 8 areas where the salmon were caught. These data show that in general the sockeye salmon from the more southerly areas had a better color. Only the Rivers Inlet area contributed any appreciable number of grade 3 canned salmon. Particular difficulty in color grading sockeye salmon from this area has been experienced by the industry.

TABLE 2

Range of colors from converted color-difference meter measurements of 60 samples of sockeye salmon before and after processing

Color attribute	Range	
	Raw	Processed
Lightness, %	9.00– 21.1	28.6– 52.5
Dominent Wavelength, mμ	591.0 –602.3	582.3–592.2
Purity, %	41.7 – 73.3	29.1– 60.0

Prediction of a value of canned salmon. The problem of grading was thus reduced to predicting the *a* value of the canned product from the color of the raw fish. The *a* readings of the raw samples had an average value of 34.7 and ranged from 16.8 to 43.3, while the *b* readings ranged from 14.9 to 25.8 with most of the readings falling between 18 and 23. As with the canned samples, the *a*/*b* ratio was found to be directly proportional to the dominant wavelength.

TABLE 3

Percentage of sockeye salmon from different areas in each color grade

Area of capture	No. of fish	% of fish in each grade when canned		
		Grade 1	Grade 2	Grade 3
West coast of Vancouver Island	40	70.0	30.0	0
Fraser River	79	73.4	25.3	1.3
Rivers Inlet	95	22.1	53.7	24.2
Juan de Fuca	78	44.9	55.1	0
Johnstone Strait	57	61.4	36.9	1.7
Bella Coola	37	54.1	43.2	2.7
Pender Harbour	10	80.0	20.0	0
Fitzhugh Sound	20	35.0	65.0	0
All areas	416	51.0	42.8	6.2

Linear correlation coefficients between the *a* values of the canned samples and the *a*, *a*/*b* and *Rd* values of the raw samples were as follows: $a = 0.637$; $a/b = 0.787$; $Rd = -0.170$. Regression equations for predicting the *a* value of the canned salmon from either the *a* or *a*/*b* value of the raw fish were as follows: $a_c = 0.550\, a_r + 0.786$ and $a_c = 18.479\, (a/b)_r - 10.801$, where the sub-letters *c* and *r* refer to canned and raw sample readings, respectively. The standard errors of estimate were 2.72 *a* units for the first equation and 2.18 for the second. From the visual color evaluations made by the panel members mentioned earlier, the permissible grade tolerances for canned salmon were estimated to be ± 1 *a* unit. This meant that *a* values as low as 19 for grade 1 and as high as 15.5 for grade 3 were permissible, whereas the *a* values for grade 2 could extend from 13.5 to 21.0. On the basis of the above specifications, the *a* value separating grade 1 and 2 canned salmon was 20, while that separating grade 2 and 3 was 14.5. From the second regression equation, the *a*/*b* ratios for the raw fish corresponding to these *a* values were calculated to be 1.67 and 1.37, as shown graphically in Figure 2. Grade specifications in terms of *a*/*b* ratios for raw fish can be stated thus: grade 1 − *a*/*b* value must exceed 1.67; grade 2 − *a*/*b* value must exceed 1.37 but must be less than 1.67; grade 3 − *a*/*b* value must be less than 1.37. When the 416 samples were graded on their *a*/*b* ratios it was found that 37 samples or 8.9% fell in the incorrect grade on the basis of the *a* value specifications and the limits outlined earlier for the canned fish. Of the incorrectly graded samples 15 of them with an average *a* value of 17.5 were placed in grade 1 instead of grade 2, 18 samples with an average *a* value of 21.9 were placed in grade 2 instead of grade 1, 4 samples with an average *a* value

of 12.9 were in grade 2 instead of grade 3, and only 1 sample was incorrectly placed in grade 3. The samples that were incorrectly graded were not from any particular area nor of any particular period of the season. The average a value of the canned samples placed in each of the 3 grades was as follows: grade 1 — 21.0; grade 2 — 19.0; grade 3 — 11.2. The per cent of fish in grades 1, 2 and 3 now was 56.9, 39.7 and 3.4 respectively. When a similar grading procedure was applied using the a values of the raw fish rather than the a/b ratios, 12.5% of the samples were incorrectly graded. This method failed particularly in correctly placing the grade 3 samples. These results indicated that the color grade of canned sockeye salmon could best be predicted from the a/b ratio of the raw fish and that the prediction within specified limits was 91% accurate.

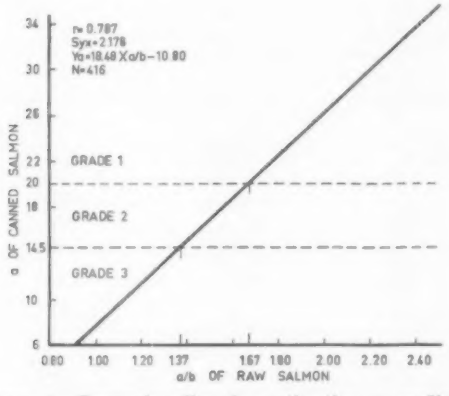

Figure 2. Regression line for estimating a readings of canned sockeye salmon.

If visual grading, based on these specifications, were desirable, at least 2 material reference standards would be required, one having an a/b ratio of 1.67 and the other having a ratio of 1.37. The a values of 20.0 and 14.5 for canned fish were applied to the first regression equation to give the best a values for such reference standards, namely 34.9 and 24.9. To retain the correct a/b ratios, the b values were calculated to be 20.9 and 18.2 respectively. The average Rd values for 76 raw samples whose a/b ratios varied from 1.65 to 1.69 was 12.9 while that for 23 samples with a/b ratios ranging from 1.30 to 1.45 was 14.1. Thus the complete specifications for such reference standards are: (a) Rd = 12.9, a =34.9, b = 20.9; (b) Rd = 14.1, a = 24.9, b = 18.2. Visual grading utilizing standards with such specifications is currently under investigation. Color grading by means of an automatic photoelectric method measuring a/b ratios of the raw fish would of course be more satisfactory. However, the commercial application of such a method will require further experimentation.

Relationship of oil content to color. The oil content of each of the 416 cans of processed sockeye salmon was determined. The data in Table 4 show that in general the more desirable color grades of sockeye salmon had a slightly higher oil content. However, on an area basis this was not always true. For example, Juan de Fuca samples had a higher average oil content (14.9%), but a lower average a value than the samples from 4 other areas. For a given area the grade 1 samples had a higher average oil content than the grade 2 samples except for the Rivers Inlet and Pender Harbour areas.

TABLE 4

Average a readings and average oil contents of sockeye salmon of 3 different color grades from 8 different areas

Area	No. of fish	Average oil content			Average a reading	Average oil content
		Grade 1	Grade 2	Grade 3		
West coast of Vancouver Is.	40	10.5	9.39	None	21.1	10.1
Fraser River	79	12.3	11.4	9.39	21.4	12.0
Rivers Inlet	95	9.58	9.67	9.48	17.0	9.58
Juan de Fuca	78	15.5	14.4	None	20.4	14.9
Johnstone Strait	57	12.4	12.3	11.5	21.2	12.4
Bella Coola	37	9.86	8.97	2.19	19.2	9.28
Pender Harbour	10	9.39	10.8	None	21.5	9.67
Fitzhugh Sound	20	9.00	7.18	None	19.6	7.82
All areas	416	11.9	11.1	9.28	19.9	11.3

Effect of increased temperature and time of processing on color. Samples from 10 sockeye salmon with an average a/b ratio of 1.74 when raw, were processed in the usual manner at 116° C. for 20 minutes after which the average a value of the canned samples was 22.6. From the same fish another 10 samples with an a/b ratio of 1.76 were processed at 121° C. for 90 minutes, resulting in an average a value of 21.1 for the canned products. A third group of 10 samples from the same fish with an average a/b ratio of 1.79 was processed at 116° C. for 2 hours, the resulting canned samples having an average a value of 21.0. These data show that a 5° C. increase in the temperature of processing or a 30-minute increase in the cooking time resulted in an increased color loss.

Effect of post-mortem storage conditions on color. Samples were taken from fresh sockeye salmon for immediate color measurements while the remainder of the fish was stored in either crushed ice or refrigerated sea water at −1.1° C. for color measurement later. Another batch of fish was divided crosswise into 2 equal parts to permit simultaneous storage in ice and refrigerated sea water. The results, shown in Table 5, indicate that the color of canned salmon was not adversely affected by the post-mortem storage of the raw fish in either ice or refrigerated sea water.

TABLE 5

The effect of post-mortem storage in ice and refrigerated sea water on the color of canned salmon

Post-mortem storage	No. of fish	Average a/b ratio of raw samples	Average a value of canned samples
None	10	1.66	21.5
10 days in ice	10	1.74	21.4
None	4	1.67	20.8
12 days in seawater at −1.1° C.	4	1.73	21.0
6 days in ice	11	1.69	20.4
6 days in seawater at −1.1° C.	11	1.72	19.1

SUMMARY

This study has shown that the Gardner Color-Difference Meter is a suitable instrument for the color measurement of raw and canned sockeye salmon. It was found that the *a* reading alone is a suitable measure of the color of canned salmon and can be best predicted from the *a/b* ratio of the raw fish. Three grades with specifications in terms of color measurements of both raw and canned fish have been proposed.

It was found that in general the canned salmon with the higher oil content had a more desirable color.

Small increases in the time and temperature of processing resulted in slightly greater color losses.

Color losses during processing were not significantly affected by the post-mortem storage of the fish in ice or refrigerated sea water prior to canning.

Acknowledgment

The authors thank Mr. I. I. Bitners for technical assistance.

LITERATURE CITED

1. Anon. Gardner Automatic Color Difference Meter. *Bull. No. 156.* Gardner Laboratory Inc., Bethesda, Md. (1956).
2. Bailey, B. E. Pigments of salmon. *J. Fish. Res. Bd. Canada*, **3**, 469 (1937).
2. Buck, R. E., and Sparks, Ruth A. Relationship of ketchup color to tomato color as determined by the Hunter instrument. *Food Technol.*, **6**, 122 (1952).
4. Canned Fish Inspection Laboratory, Vancouver, B. C. (Personal communication).
5. Charnley, F. Color in canned salmon. Fish Res. Bd. Canada, *Prog. Rep. Pac.*, **29**, 12 (1936).
6. Charnley, F., and Bolton, R. S. Relation between intensities of colors of muscle tissue of British Columbia salmon. *J. Soc. Chem. Ind.*, **64**, 86 (1945).
7. Friedman, M. E., Marsh, G. L., and Mackinney, G. On color in tomato products. *Food Technol.*, **6**, 395 (1952).
8. Hardy, A. C. *Handbook of Colorimetry.* 1936. Color Measurement Laboratory, Massachusetts Institute of Technology, Cambridge.
9. Hunter, R. S. Photoelectric color-difference meter. *J. Optical Soc. Am.*, **38**, 661 (1948).
10. Judd, D. B. *Color in Business, Science and Industry.* 1952. John B. Wiley and Sons, New York, N. Y.
11. Robinson, W. B., Wishnetsky, T., Ransford, J. R., Clark, W. L., and Hand, D. B. A study of methods for the measurement of tomato juice color. *Food Technol.*, **6**, 269 (1952).
12. Robinson, W. B., Ransford, J. R., and Hand, D. B. Measurement and control of color in the canning of tomato juice. *Food Technol.*, **5**, 314 (1951).
13. Schmidt, P. J. (Unpublished data, Fish. Res. Bd. Canada, Vancouver, B. C.)
14. Schofield, R. K. The Lovibond Tintometer adapted by means of the Rothamsted device to measure colors on the C.I.E. system. *J. Sci. Instruments*, **16**, 74 (1939).
15. Shah, J. N., and Worthington, O. J. Comparison of several methods and instruments for specifying the color of frozen strawberries. *Food Technol.*, **8**, 121 (1954).
16. Younkin, S. G. Color measurement of tomato purees. *Food Technol.*, **4**, 350 (1950).

A Method of Evaluating Modifications in Sample Presentation

To the Hunter Color-Difference Meter[a, b]

(Manuscript received August 13, 1957)

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STUDIES MADE in this laboratory on the role of sweeteners in fruit preservation *(1)* entailed measurements obtained by means of the Hunter Color and Color-difference Meter. Difficulties were experienced with the usual method of sample presentation *(2)* due to color differences between fruit pieces and sirup, inability to obtain uniform samples without destroying the intact fruit or berries, and slowness of the method. The sample presentation method of Tinsley, Cain, and Sidwell *(5)*, whereby a circular dish is suspended above the meter by a spindle attached to the lid of the dish, minimized the inaccuracy due to non-uniformity of sample and also permitted samples to be presented more rapidly. When this method was used, however, it was noticed that preserves and other viscous materials formed a tacky undesirable seal between the dish and its lid. In addition, the sample dish frequently rotated in a plane which was not perfectly horizontal, and the means of rotating the dish did not allow the standard tiles to be used in the same position as the sample dish.

Accordingly, the Hunter meter and its use have been further modified to eliminate some of the objections to the method of Tinsley, Cain and Sidwell.

Since experience has indicated that color differences between samples examined in this laboratory are small, it is extremely important that any modification does not decrease the sensitivity of the meter and that differences between duplicate readings be minimized. It is the purpose of this report to present a means of evaluating the sensitivity of the modified meter to small color differences. For this evaluation the colors of certain chemicals were varied systematically by the addition of lighter or darker materials and the samples presented to the meter in different ways. Differences in scale values were then evaluated in terms of the meter's ability to "see" small color variations.

EXPERIMENTAL

Modification of the meter. Figures 1 and 2 show the modified Hunter meter and the modified means of presenting the sample to the meter. The dish is supported by 3 vertically-oriented wheels and rests against the 2 horizontally-rotating wheels.

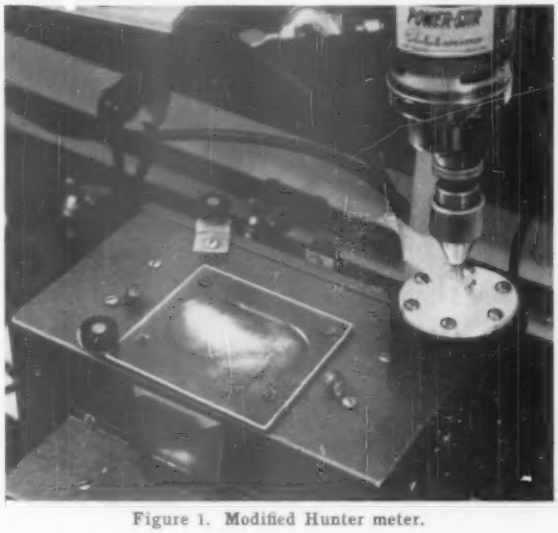

Figure 1. Modified Hunter meter.

Spring tension keeps the drill powered rubber wheel tilted toward the dish and the driving wheel firmly against the side of the dish. As shown in Figure 2, a considerable portion of the sample is presented to the instrument. The distance between the dish and the meter is about ¼ inch.

Test materials. Various food products and chemicals were used to test the response of the instrument to samples placed directly upon it and rotated above it. Among these materials were strawberry preserves, green beans, corn, picric acid, calcium chromate, green chalk and artists color, and a powdered red food dye *(cherry red)*.

Procedures. *A. Sample rotated above instrument.* As indicated by Figure 2, the sample was placed in a circular plastic dish about 6 inches in diameter and 1¼ inches high. The dish was supported above the instrument as noted above. Rheostatic control of the drill speed allowed the dish to be rotated at 30-40 r.p.m.; no difference in instrument reading or centrifugal disintegration of the sample was noted in this speed range.

B. Sample placed on instrument. The same sample used in the circular dish was placed in small rectangular plastic dishes about 1½ inches high and a little larger than the specimen area of the exposure unit. Two of these dishes were needed to contain the entire sample. Three measurements were taken progressively along the axis of the dish (the whole exposure window of the instrument being covered at all times), and one reading with the dish placed across the exposure window. Readings were repeated until duplicates checked within 0.3 units on each scale. All the lengthwise readings obtained from the 2 dishes were averaged and this average value used in the calculations. The 'across' readings were treated similarly.

[a] Technical Paper No. 1069, Oregon Agricultural Experiment Station.

[b] Supported by a grant from the Sugar Research Foundation, New York City.

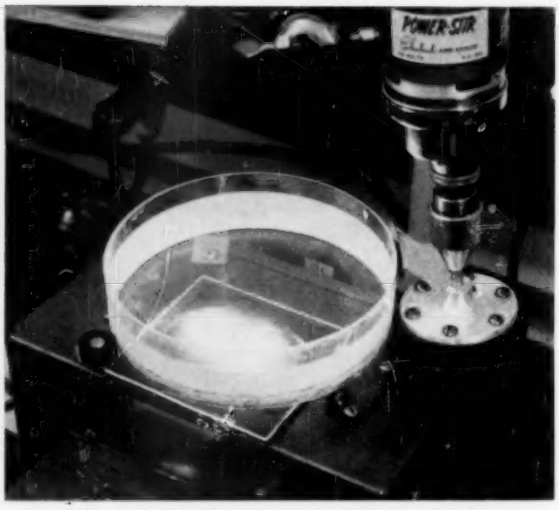

Figure 2. Modified means of presenting sample.

C. Color measurements of fruits and vegetables. Strawberry preserves, green beans, and whole kernel corn were measured as they came from the container. The beans and corn were subsequently homogenized and the color values of the homogenate also measured. The "L", "a_L" and "b_L" scales were used for all color measurements. The instrument was standardized against National Bureau of Standards porcelain tiles as follows: for strawberries, the SKC 70 tile having scale values L = 27.0, a_L = 48.8 and b_L = 16.4; for green beans, the SKC 15 tile having scale values L = 58.2, a_L = 21.0, b_L = 14.5; for corn the SKC 35 tile having scale values L = 73.4, a_L = 1.0, b_L = 31.7.

D. Color measurements of chemicals. The chemical compounds mentioned above were measured on the L, a_L and b_L scales, using the same tiles mentioned previously. The color values of the chemicals were then altered slightly by the addition of small amounts of charcoal, calcium carbonate, or chemicals of different colors.

RESULTS AND DISCUSSION

Since this laboratory is concerned mainly with yellow, green, and red fruits and vegetables, these 3 colors were used to evaluate the instrument. The modification of the meter did not allow the circular dish to be placed directly upon the exposure unit and it was necessary to transfer the sample to smaller plastic dishes. All dishes used were examined carefully for clarity and freedom from scratches.

The data in Table 1 show the color values of different food products when the samples are rotated above the instrument and placed directly on the exposure unit. It is noted that the variation in color values seems to be partially a function of the specific food product and its form. Whole kernel corn, for example, placed on the meter shows a difference of about 1½ to 2 units in b_L value from the same sample rotated above the meter. Blended corn, in contrast, shows almost the same b_L regardless of presentation method. Extremely heterogeneous materials like strawberry and cherry preserves may show marked differences in color values depending on whether the dish is placed across the exposure unit or moved lengthwise progressively along the unit. Since these differences are presumably due to the ratio of solid material to sirup or brine, the large circular dish offers the advantage of allowing the worker to obtain an integrated color value representative of the entire sample. The data obtained from the use of standard chemicals, all presented as uniform powders, show that differences in color values cannot be attributed solely to non-uniformity of sample; the method of presentation affects the color values obtained. As noted by Tinsley, Cain and Sidwell *(5)*, L values are generally lower when the samples are presented by the rotating dish method. How-

TABLE 1

Influence of method of presentation upon Hunter values

Substance	Method of presentation: Lengthwise			Across			Rotated		
	L	a_L	b_L	L	a_L	b_L	L	a_L	b_L
Corn, whole kernel No. 1	59.1	0.9	27.1	59.8	0.9	27.6	58.5	1.5	29.1
Corn, whole kernel No. 2	61.9	0.8	27.5	61.6	1.1	28.1	61.3	1.2	30.4
Corn, whole kernel No. 3	61.8	0.9	28.6	62.2	0.8	28.8	60.5	1.1	30.0
Corn, blended No. 1	65.6	−0.4	31.4	65.7	−0.3	31.8	65.3	−0.3	31.3
Corn, blended No. 2	66.4	−1.0	31.0	66.4	−0.8	31.5	65.7	−0.7	30.8
Corn, blended No. 3	68.3	−1.5	31.0	68.2	−1.4	31.5	66.1	−0.8	30.9
Beans No. 1	33.6	−8.1	9.7	32.8	−7.6	9.6	29.9	−8.0	9.0
Beans No. 2	32.9	−7.7	9.3	32.3	−7.5	9.4	29.8	−7.3	9.2
Beans No. 3	32.5	−8.1	9.1	32.7	−8.3	9.8	29.7	−7.9	9.3
Beans, blended No. 1	40.9	−10.8	14.0	40.6	−10.4	13.8	38.7	−10.6	13.9
Beans, blended No. 2	40.8	−10.3	13.2	40.6	−9.8	13.2	39.4	−10.5	14.0
Beans, blended No. 3	40.5	−10.8	14.2	39.7	−10.3	14.0	38.6	−10.7	14.1
Strawberry Preserves No. 1	13.5	2.2	1.4	11.5	2.2	1.2	13.6	6.1	6.2
Strawberry Preserves No. 2	13.3	3.0	2.2	12.9	3.1	2.0	13.4	5.9	6.2
Strawberry Preserves No. 3	13.6	3.4	2.0	12.6	3.5	2.0	13.6	5.6	5.8
Cherry Preserves No. 1	13.0	4.3	5.1	12.2	4.3	5.1	12.6	4.9	5.4
Cherry Preserves No. 2	14.1	5.0	5.6	13.1	5.1	6.0	12.8	5.8	5.8
Cherry Preserves No. 3	12.8	2.9	1.3	11.4	2.5	1.0	12.7	5.7	5.8
Picric Acid	78.4	−6.5	29.1	78.2	−6.6	29.6	77.3	−6.5	28.8
Green Chalk	42.5	−17.7	6.1	41.8	−18.0	6.5	41.3	−18.2	7.0
Cherry Red	29.1	16.2	7.5	27.9	16.7	7.5	26.5	17.3	8.1

ever, when the standard plaques were presented to the meter at the same distance as the rotating dish, the values agreed on each scale within 0.2 units with those obtained with the plaque resting on the meter. This agreement is in line with that mentioned by Francis *(3)*. Presumably, the difference in behavior between the standard plaques and actual samples is due to the smooth uniform surface of the former.

This laboratory uses the Hunter meter as a color-difference meter to evaluate gross changes in appearance of foods as a result of processing and storage. More attention was paid, therefore, to the differences in readings obtained within a presentation method using different samples than to calculations of dominant wave lengths and per cent purity from the actual dial values. The calculated dominant wave length would depend upon dial readings but, since dial readings or dominant wave lengths can be correlated with color score or acceptability, any reliable presentation method would be valuable to the food scorer. In this study readings taken with the dish placed across the exposure unit are compared with those taken with the dish rotated above the unit. Many commonly available chemicals, dyes and other powders were investigated for use as standard samples, and those which yielded color values which approximated that of the standard plaque or the food under investigation were selected.

The data in Table 2 indicate the changes in L, a_L and b_L values as material were mixed, lightened or darkened. The results show that small color differences were measured effectively by either method. Also, the differences between the highest and lowest L, a_L and b_L readings for each group of dyes are approximately the same for the spot method and the rotational method, indicating no diminution in overall sensitivity of the modified instrument. Consequently, the precision with which each method measures an individual reading becomes of prime importance. The analysis of variance summarized in Table 3 indicates that the rotational method is much more precise than the spot reading method. The "efficiency ratio" listed in Table 3 is the ratio of the variances and indicates the number of spot readings needed in place of each rotational reading to obtain the same standard error of the mean. For example, the L reading for picric acid shows an efficiency ratio of 1.33; this means that 1.33 spot readings are needed to give the same accuracy as one rotational reading. In many cases six or seven times as many readings are needed under the spot reading method, and for b_L of *cherry red* thirteen times as many spot readings are needed to give the same precision as one rotational reading.

Hunter *(4)* has shown that the absolute accuracy of a reading is a function of the color difference between the color of the sample and that of the reference sample. The method described herein suggests a means of minimizing, or at least standardizing, the inaccuracy. By using suitable materials a dye mixture very close in color value to that of a food being analyzed routinely can be prepared and then used as a secondary standard.

SUMMARY

The Hunter meter and sample presentation method have been modified to eliminate certain objections to previous methods. The modified instrument allows the sample dish to rotate in a plane parallel to the

TABLE 2

Sensitivity of different methods to small color differences

Substance	Modification	Hunter values spot readings			Differences between readings			Hunter values rotated			Differences between readings		
		L	a_L	b_L	L	a_L	b_L	L	a_L	b_L	L	a_L	b_L
Picric Acid	A	78.3	6.6	29.6				77.3	6.5	28.8			
	B	76.5	6.2	32.0	1.8	0.4	2.4	75.6	6.2	31.6	1.7	0.3	2.8
	C	74.9	5.4	34.7	1.6	0.8	2.7	73.6	5.5	35.1	2.0	0.7	3.5
	D	69.5	7.2	26.3	5.4	1.8	8.4	68.1	7.5	27.1	5.5	2.0	8.0
	E	66.2	7.2	23.7	3.3	0.0	2.6	65.1	7.2	24.3	3.0	0.3	2.8
A = pure picric acid; B = A plus chroomate; C = B plus additional chromate; D = C plus charcoal; E = D plus additional charcoal.													
Green Chalk	A	41.8	−18.0	6.5				41.3	−18.2	7.0			
	B	43.3	−19.5	8.0	1.5	1.5	1.5	42.8	−19.8	8.3	1.5	1.6	1.3
	C	42.6	−19.9	8.9	0.7	0.4	0.9	42.1	−20.1	9.4	0.7	0.3	1.1
	D	40.4	−16.1	7.4	2.2	3.8	1.5	39.7	−16.0	8.0	2.4	4.1	1.4
A = green chalk; B = A plus $CaCO_3$; C = B plus green tempera; D = C plus Cherry red.													
Cherry Red	A	27.9	16.7	7.5				26.5	17.3	8.1			
	B	27.5	14.5	7.5	0.4	2.2	0.0	25.9	15.3	8.3	0.6	2.0	0.2
	C	28.3	15.3	7.4	0.8	0.8	0.1	26.9	16.0	8.3	1.0	0.7	0.0
	D	28.8	15.7	7.5	0.5	0.4	0.1	27.7	16.4	8.1	0.8	0.4	0.2
	E	29.7	16.5	7.7	0.9	0.8	0.2	28.5	17.1	8.2	0.8	0.7	0.1
A = pure dye; B = A plus charcoal; C = B plus $CaCO_3$; D = C plus additional $CaCO_3$; E = D plus additional $CaCO_3$.													

TABLE 3

Variance of spot readings and rotational readings

Substance		Variance spot readings	Variance rotational reading	Efficiency ratio
Picric Acid	L	.0566	.0426	1.33
	a_L	.0732	.0214	3.42
	b_L	.0843	.0541	1.56
Green Chalk	L	.0917	.0150	6.11
	a_L	.0475	.0060	7.92
	b_L	.0142	.0070	2.02
Cherry Red	L	.0702	.0155	4.53
	a_L	.0535	.0102	5.23
	b_L	.0278	.0021	13.0

top face of the meter and allows the standard tiles to be used in the same position as the sample dish.

Certain colored chemicals were used to determine the sensitivity of the modified meter to small differences in color. Compared to the original instrument the modified meter is equally sensitive but more precise and reliable in measuring color differences.

Acknowledgments

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LITERATURE CITED

1. Aref, M., Sidwell, A. P., and Litwiller, E. M. The effects of various sweetening agents on frozen strawberries for preserve manufacture. *Food Technol.*, 10, 293–297 (1956).
2. Description and Instructions for Hunter Color and Color-Difference Meter. Henry A. Gardner Laboratory, Inc., Bethesda, Md., June 1950.
3. Francis, F. J. A method of measuring the skin color of apples. *Proc. Am. Soc. Hort. Sci.*, 60, 213–220 (1952).
4. Hunter, R. S. Photoelectric tristimulus colorimetry with three filters. *J. Opt. Soc. Am.*, 32, 509 (1942).
5. Tinsley, Ian J., Sidwell, A. P., and Cain, R. F. Methods of presenting raspberry and strawberry samples to the Hunter Color and Color-Difference Meter. *Food Technol.*, 10, 339–344 (1956).

Radiation-Induced Changes in Bread Flavor[a,b]

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Ionizing radiations, although capable of sterilizing, pasteurizing, or deinfesting various food products, produce concomitant flavor, textural, nutritional, and other changes *(10)*. In particular, ionizing radiations have been shown to destroy certain grain-infesting insects *(1, 6, 9)*. These grain-insect studies and other studies *(3, 8)* have also revealed some of the undesirable changes in the finished flour product that are attributable to the radiation treatment. This paper describes work undertaken to establish a treatment level threshold at which flavor change could be detected in bread made from both milled irradiated wheat and irradiated flour. No attempt was made to mitigate, by chemical or physical means, the associated flavor change. One physical property, loaf volume, was measured.

EXPERIMENTAL

Approximately 100 lb. of hard red spring wheat and 70 lb. of an all-purpose flour of comparable protein content were irradiated with a 1,000,000-volt, resonant-transformer, electron beam generator *(7)*. Dose measurements were based on ionization chamber dosimetry.

All bread used in the tests was made by the recipe given in Table 1. The actual amounts of ingredients used yielded a 1½ pound loaf. The tests were conducted over a 4-month period with limits of 3 tasting days a week and 2 judgments a day. All bread was tasted within a few hours after baking; loaf weights and volumes were measured one hour after baking. The bread samples, ½ x 3 x 1 inches, were presented to the 7 male panel members (not all of whom were present each tasting day) according to randomly selected triangle arrange-

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[b] Presented before the Seventeenth Annual Meeting of the Institute of Food Technology, Pittsburgh, Pa., May 16, 1957.

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TABLE 1

Bread recipe

Ingredient	Relative weight
Flour	100
Yeast	1.58
Sugar	2.95
Salt	1.47
Non-fat dry milk solids	4.84
Hydrogenated shortening	5.05
Potassium bromate[1]	0.0005
Water	63.2

[1] Added only to the non-commercial flour.

ments of the irradiated and non-irradiated (control) bread samples.

The panel members were instructed to use the warm coffee and water rinses as they wished and to wait 5 minutes before the second group of samples for the day. The tests were conducted in two consecutive series; first, bread made from flour and, second, bread made from flour milled from irradiated wheat. During the first series the panel members were informed of the correctness of their judgments; however, this practice was abandoned during the second series. Since the 100 lb. of wheat used in the second series was all irradiated on the same day, and since the bread was tasted over a period of several weeks, the 2 treatment levels tested on any particular day were chosen by random numbers to avoid the introduction of any systematic error in the results due to a possible change in irradiation-induced flavor with time. To lessen any possible flavor carry-over, the lower treatment level was tasted first on each tasting day. Shortly after the first series was started, the panel was asked to not only identify the odd sample, but to tell whether it was irradiated or not and to state a preference.

The threshold is that defined by Bierman, Proctor, and Goldblith *(2)*, the dose at which 50% of the judgments (above chance) are correct. Since the responses at each particular dose are quantal in nature, i.e., the judge is right or wrong, the per cent of correct judgments will be binomially distributed. The logarithm of the dose was chosen in the expectation that it would be a normalizing transformation of the distribution function. The final analysis was made, using the probit of the per cent of correct judgments adjusted by Abbott's formula and the logarithm of the dose *(5)*. The weighting coefficients used were those required by the fact that one-third of the judgments will be correct on a purely chance basis; this modification avoids the introduction of any spurious precision in the threshold limits. The loaf volumes between treatments were analyzed by co-variance to correct for the daily variation in the control loaf volumes. The loaf volume means were compared using Studentized multiple ranges *(4)*.

RESULTS AND DISCUSSION

The probit lines coresponding to judgments made on irradiated wheat and irradiated flour are given in Figure 1. Each plotted point represents 17 or more judgments. The extension of the probit line for flour beyond the plotted points is justified by the existence of a point at 500,000 rep at which all of 10 judgments were correct. This point can not be plotted because its probit is infinite. These lines and the corresponding thresholds are based on the judgments of four of the panel members (the same four in both cases). These judges were selected to represent the data on the basis of their discriminatory ability as evidenced in preliminary tests, and on the basis of attendance at the tasting sessions. The judgments of all the panel members are given in Tables 2 and 3 in which are included the additional results with respect to ability to tell whether the odd sample was irradiated.

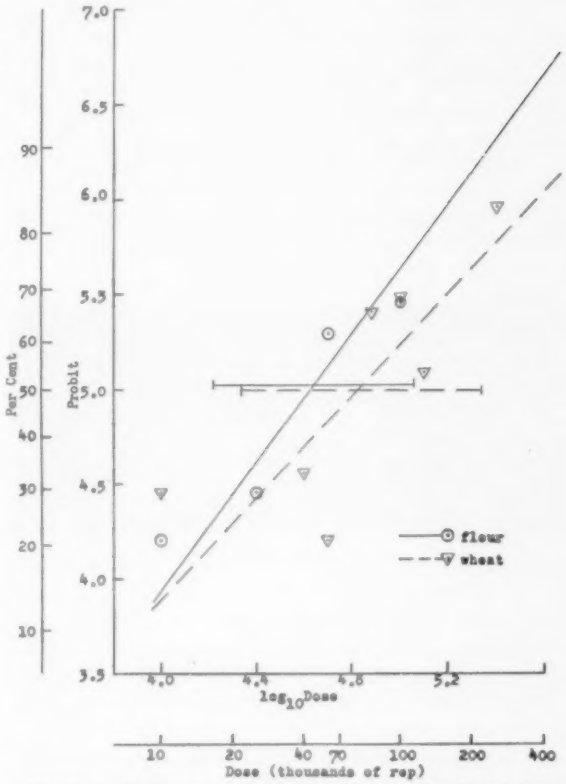

Figure 1. Probit lines for bread made from irradiated flour and irradiated wheat.

The levels of significance were determined from published tables *(11, 12)*.

TABLE 2

Taste panel results (all judges)
Irradiated flour

Dose (rep)	Correct selection of odd sample	Correct identification of odd sample treatment
1.0×10^6	15/29*	3/17
2.5×10^6	22/46*	18/46**
5.0×10^6	25/44**	12/34*
1.0×10^5	27/38**	11/28**
5.0×10^5	17/20**	12/15**

*Significant at the 5% level.
**Significant at the 1% level.

TABLE 3

Taste panel results (all judges)
Irradiated wheat

Dose (rep)	Correct selection of odd sample	Correct identification of odd sample treatment
1.0×10^6	12/25	7/25
4.0×10^6	12/28	11/28**
5.0×10^6	14/26*	8/26
7.5×10^6	16/20**	12/20**
1.0×10^5	18/25**	18/25**
1.25×10^5	14/22**	12/22**
2.5×10^5	20/22**	17/22**

*Significant at the 5% level.
**Significant at the 1% level.

In the case of bread made from irradiated flour, two doses were given that were not included in the probit analysis. Figure 2 shows control 500,000, 1,000,000 and 10,000,000-rep loaves. These latter 2 loaves were those excluded from the final analysis. One taste test was conducted with the 1,000,000-rep loaf; the samples were placed under red lamps to avoid a choice being made on the basis of the obvious color difference. The 6 judgments were all correct; therefore, this dose was eliminated from further trial.

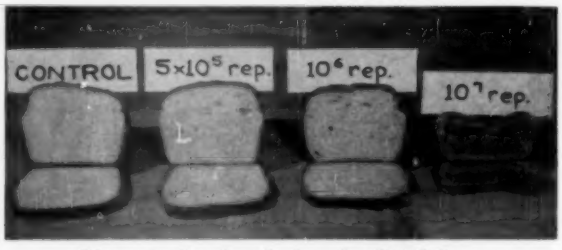

Figure 2. Bread made from irradiated flour.

The 10,000,000-rep loaf had such a disagreeable odor and taste, to say nothing of the appearance, that it was not tested at all. Such high doses, well above those necessary to kill insects, were employed to ensure exceeding the threshold dose.

The group threshold established by the probit analysis lies at about 50,000 rep in the case of both breads. The 95% confidence limits are rather wide in both instances; nevertheless, the analysis has served to establish a threshold and its limits. Since this group threshold lies in the neighborhood of the treatment levels required to deinfest grain, some additional treatment may be required to reduce the off-flavors. The general tendency of the judges is toward being able to tell which sample is irradiated and then not to prefer it; of the 85 correct identifications of the odd sample in series two, 84 preferences were for the non-irradiated sample. There is no way to evaluate to what extent a knowledge that a particular sample has been irradiated prejudices preference. Loaf volumes were not significantly different among treatments up to 500,000 rep in the case of bread made from irradiated flour; but in the case of bread made from the milled irradiated wheat, dose levels in the mid-range (50,000 rep) gave significantly higher volumes than at 250,000 rep (Table 4). No analysis of variance is required to note the significant volume decrease at the 10,000,000-rep level.

TABLE 4

Adjusted loaf volume means (cc.)
Irradiated wheat

Dose (rep)	No. of loaves	Volume
1.0×10^4	5	2831
4.0×10^4	5	2866[1]
5.0×10^4	6	2890[2]
7.5×10^4	5	2815
1.0×10^5	5	2746
1.25×10^5	5	2821
2.5×10^5	5	2704

[1] Significantly higher than the 250,000-rep loaf at the 5% level.
[2] Significantly higher than the 100,000-rep and 250,000-rep loaves at the 5% level.

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LITERATURE CITED

1. Baker, V. H., Taboada, O., and Wiant, D. E. Lethal effect of electrons on insects infesting wheat and flour—Part I. *Agricultural Engineering*, **34**, 755 (1953).
2. Bierman, G. W., Proctor, B. E., and Goldblith, S. A. Radiation preservation of milk and milk products. II. Off-flavors in milk and cream induced by ionizing radiations as judged by organoleptic tests. *J. Dairy Sci.*, **39**, 379 (1956).
3. Brownell, L. E., Harlin, H. A., and Nehemias, J. V. A preliminary study of the effect of gamma radiation on the baking quality of flours. *Food Technol.*, **9**, 620 (1955).
4. Duncan, D. B. Multiple range and multiple F tests. *Biometrics*, **11**, 1 (1955).
5. Finney, D. J. *Probit Analysis.* 2nd ed., 1952. The Cambridge University Press, London.
6. Hassett, C. C., and Jenkins, D. W. Use of fission products for insect control. *Nucleonics*, **10** (12), 42 (1952).
7. Knowlton, J. A., Mahn, G. R., and Ranftl, J. W. The resonant transformer: a source of high-energy electrons. *Nucleonics*, **11** (11), 64 (1953).
8. Milner, M., and Yen, Y. Treatment of wheat with ionizing radiations. III. The effect on breadmaking and related properties. *Food Technol.*, **10**, 528 (1956).
9. Proctor, B. E., Lockhart, E. E., Goldblith, S. A., Grundy, A. V., Tripp, G. E., Karel, M., and Broglé, R. C. The use of ionizing radiations in the eradication of insects in packaged military rations. *Food Technol.*, **8**, 536 (1954).
10. Reddish, G. F. (Ed.) *Antiseptics, Disinfectants, Fungicides, and Chemical and Physical Sterilization.* 1st ed., 1954. Lea and Feiberger, Philadelphia, Pa.
11. Roessler, E. B., Baker, G. A., and Amerine, M. A. One-tailed and two-tailed tests in organoleptic comparisons. *Food Research*, **21**, 117 (1956).
12. Roessler, E. B., Warren, J., and Guymon, J. F. Significance in triangular taste tests. *Food Research*, **13**, 503 (1948).

The Influence of Test Location and Accompanying Sound in Flavor Preference Testing of Tomato Juice[a]

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THE PHYSICAL CONDITIONS under which a flavor test is conducted are important. This is due to the need for good experimental control, for mechanical efficiency, and for anticipating, to the extent possible, the effects of the surrounding environment on test results. The extent to which the environment enters into the test results can not always be ascertained. In the planning of tests attention should be paid to the place where taste tests are to be held and to reducing or eliminating distractions which may occur during the test.

Crocker, Sjöström and Tallman *(2)* have suggested various factors that may enter into a taster's judgment of food quality, among which is the physical setting. Crocker *(1)* believes that sound may also have an influence, that a loud noise may prevent entirely the ability to smell or taste, or, conversely, that "softly played dinner music can create an environment favorable for elegant dining." These factors, however, have not received due attention in published research. This study was conducted in order to ascertain whether the location of the test (within the choices available for this work) or the presence of generalized sound affected the results obtained by a flavor preference panel in evaluating tomato juice.

EXPERIMENTAL PROCEDURE

A series of 6 flavor tests, on 6 days, was conducted in 3 different locations under conditions of sound and quiet. The same taste panel, consisting of unscreened and untrained men and women college students, was used throughout the series. Two different trays of samples were presented at each sitting in order to obtain 2 sets of observations for evaluation.

At each test, three cups of tomato juice were served on a single tray to each taster. One of the cups, marked R and containing two ounces of juice, was the reference sample. The other 2 cups, each containing 1½ ounces of juice, were marked only with 4-digit code numbers, selected from a random number table.

The tomato juice for these tests was obtained from single lots of 3 brands of commercially packed juice. On one of the 2 trays presented at a sitting, the reference and one of the coded samples consisted of brand A. The other coded sample was brand B. On the second tray, the reference and one coded sample were brand C; the other coded sample was brand B. The order in which the 2 trays were presented was randomized from taster to taster.

On each testing day, the juice was prepared for serving by blending the contents of a uniform number of 46-ounce cans taken from the same cases of the same lot (identified by packer's code number) for brand A, brand B, and brand C, separately. The juice was held during each test in large blending pans and served at room temperature of 70° F., plus or minus 3 degrees. Pans were kept covered during the tests except when the product was being dispensed by ladle.

A printed ballot was given each taster with each tray of samples (Figure 1). This ballot instructed the taster to compare the flavor of each coded sample directly with the flavor of the reference sample, then to record in the columns provided his judgment as to whether he considered the flavor slightly, moderately, or much better or poorer than the reference flavor, or neither better nor poorer than the flavor of the reference.

Date:_____ Product:_____ Name:_____

Test Number:_____

INSTRUCTIONS:

The side dish contains a reference sample. Compare the flavor of each sample directly with the flavor of the reference sample.

(a) Taste the reference and the sample as many times as necessary;

(b) Write the number which is on sample container in a space after the statement which indicates your judgment:

Much better flavor than reference
Moderately better flavor
Slightly better flavor
Neither better nor poorer flavor
Slightly poorer flavor
Moderately poorer flavor
Much poorer flavor than reference
Comments:

Be sure your name in written on this ballot. When finished, please return tray to serving table, fold the ballot once and place it in ballot box.

THANK YOU.

Figure 1. Flavor test ballot.

Locations. Three locations were chosen for the tests in proximity to the preparation kitchens of the Food Technology Building, Oregon State College. These consisted of: (a) individual taste testing booths equipped with an individual basin, stool, service counter, and sliding-door opening through which the samples were served; (b) an open rectangular room approximately 25 feet wide and 30 feet long, surrounded on 3 walls with an open counter on which the samples were served to the tasters as they were seated on stools; (c) an auditorium approximately 75 feet long, 50 feet wide, and 25 feet high, at the front of which 3 rectangular tables were placed on which the samples were served to the seated tasters.

Each location was lighted for the test by white incandescent room lights. Room temperatures were approximately the same in each. Printed placards were placed prominently on the walls instructing the tasters not to converse during the tests. No verbal instructions were given to the tasters by the serving attendants.

[a] Technical Paper No. 1029, Oregon Agricultural Experiment Station.

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Sound. Each of the locations was used on 2 days. On one of these days quiet was maintained throughout the entire test. Prominent placards on the walls instructed tasters and serving attendants to maintain silence. On the other day, controlled sound was introduced into the tasting area. Placards requesting no conversation remained on the wall at this time.

The controlled sound consisted of a tape recording of the noises of a large restaurant. This was played continuously throughout the test on an Eicor, Model 230, tape recorder, hidden from the view of the tasters. The tape recording was prepared from a commercial transcription with the aid of the technical staff of KOAC radio station, Oregon State College, Corvallis. Sounds emanating from the tape were the intermixture of clattering dishes and utensils, scuffing and scraping, voices, and background noises. No intelligible words were heard. Intensity of the sound in each location was maintained at a uniform level of 80 decibels, plus, or minus 5 decibels, established by means of meter measurement with respect to the positions occupied by the tasters while tasting. This decibel level represented approximately the normal intensity of general sound to be encountered in a large restaurant.

The order in which the 6 tests comprising the 3 locations under conditions of sound and quiet were conducted was randomized. Eighty-four tasters rendered judgments under the 6 conditions for products CCB, whereas 83 judgments were obtained under the 6 conditions of location and sound for the products AAB.

ANALYSES AND RESULTS

Judgments obtained from the individual tasters were transposed to numerical scores on the basis of a 7-point scale. Scores were then tabulated for the coded samples according to the conditions of location and sound. Scores for the coded samples which were identical to the reference were established on the basis of the 7 points of the ballot, whereas scores for the coded samples which were not identical to the reference were recorded on the basis of their difference from the score of the identical sample. This provided an anchor for these judgments, inasmuch as their true value could not be known. Effects of the testing conditions on the preference for these samples could be viewed in terms of whether the difference in preference between them and the coded control samples was caused to change.

Analyses of variance were conducted for the scores obtained for the samples which were identical to the reference and for the scores of the nonidentical samples under the 6 conditions of location and sound. The analysis of the scores of the coded identical samples in both combinations revealed no significant differences in the panel mean scores obtained under the various conditions of location and sound or quiet. The analyses (Tables 1 and 2) indicated that there were some differences in preferences among individual tasters and that in the case of product C there were significant interactions between the tasters and the locations, the tasters and the sound, and the sound and the locations, implying that the reactions of tasters were not all the same under the conditions. Nevertheless, the preference finding of the panel remained the same in the 3 locations and whether there was sound or quiet.

Analysis of variance of the scores of coded sample B in both combinations also indicated no significant differences in panel mean scores obtained under the various locations or conditions of sound or quiet. The analyses (Tables 3 and 4) again revealed that all tasters did not agree with each other in their preferences. The general mean scores for product B were 5.57 with reference A and 5.84 with reference C.

TABLE 1

Effect of location and sound, duplicate sample A

Analysis of variance

Variation source	Degree of freedom	Mean square	F
Sound	1	0.3936	0.44
Location	2	0.6888	0.77
Sound x Location	2	1.5201	1.69
Tasters	82	2.1503	2.39**
Sound x Tasters	82	0.9261	1.03
Location x Tasters	164	0.2786	0.75
Error	164	0.9002	.....
Total	497	.....	

**Significant at 1%.

TABLE 2

Effect of location and sound, duplicate sample C

Analysis of variance

Variation source	Degree of freedom	Mean square	F
Sound	1	0.8750	1.81
Location	2	1.0139	2.10
Sound x Location	2	1.6250	3.37*
Tasters	83	1.1380	2.36**
Sound x Tasters	83	2.2083	4.58**
Location x Tasters	166	1.7267	3.58**
Error	166	0.4824	.....
Total	503	.....	

*Significant at 5%.
**Significant at 1%.

SUMMARY AND CONCLUSIONS

These tests have demonstrated that, with respect to tomato juice as evaluated by a college student panel, the 3 locations in which the flavor tests were con-

TABLE 3

Effect of location and sound, sample B with reference A

Analysis of variance

Variation source	Degree of freedom	Mean square	F
Sound	1	0.0984	0.06
Location	2	0.2892	0.17
Sound x Location	2	4.9719	2.85
Tasters	82	3.7366	2.14**
Sound x Tasters	82	1.5293	0.88
Location x Tasters	164	1.7160	0.98
Error	164	1.7442	.....
Total	497	.....	

**Significant at 1%.

TABLE 4

Effect of location and sound, sample B with reference C

Analysis of variance

Variation source	Degree of freedom	Mean square	F
Sound	1	0.6429	0.31
Location	2	5.9068	2.84
Sound x Location	2	1.1486	0.55
Tasters	83	5.5067	2.65**
Sound x Tasters	83	2.2041	1.06
Location x Tasters	166	2.0207	0.97
Error	166	2.0791	.....
Total	503	.....	

**Significant at 1%.

ducted did not alter the preference findings obtained from the taste panel, and that the presence of generalized sound which is typical of a large restaurant, as contrasted with quietude, did not affect the preference results obtained. The analyses indicate that all tasters did not agree in their individual preferences, but panel preference did not change from location to location nor with sound or quiet. Flavor preference for tomato juice by this panel could be as well ascertained in any of the 3 locations examined and without concern for restaurant-like sound or maximum quiet.

LITERATURE CITED

1. Crocker, E. C. The technology of flavors and odors. *Confectioner*, 34 (1), 7–10 (1950).
2. Crocker, E. C., Sjöström, L. B., and Tallman, G. B. Measurement of food acceptance. *Ind. Eng. Chem.*, 40, 2254–2257 (1948).

Trimming Time and Yield Factors in Processing of Applesauce

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Prior to the early 1930's, most of the apples that the processors received were of cider grade and were used to produce vinegar. With the loss of the export market and greater competition from other produce, the fresh apple markets began to demand higher quality apples. This emphasis on better fruit brought about changes in grade requirements for packed fresh apples, resulting in greater quantities of larger and better quality apples being thrown on to the cull piles. As the cull piles increased, the cost of disposal mounted. Also, the loss of the export market resulted in a situation where some varieties, principally York Imperial, were no longer desired for the fresh market.

The processing industry recognized the potentialities of these cull piles and of the less desirable fresh market varieties. The fruit growers were interested in obtaining an outlet for cull fruit and fruit of less desirable fresh market varieties even though the price received might be low. At first, canned apple slices were produced from the larger apples, and apple butter, apple jelly, and cider from the small ones; vinegar was produced from peels, cores, and trim waste. Later, canned applesauce, as well as pectin and other products, was manufactured.

As consumer demand for processed apple products increased, industry requirements for processing apples exceeded the supply that the cull piles had to offer. As a result of this trend it became necessary for the processing industry to purchase apples in competition with the fresh fruit market. This change in source of supply meant that although the unit cost of the raw material to the processors would be greater, the quality of the raw product and recovery of finished product would be higher. After this change, many apple growers began producing their crops solely for the processing industry. The growers began to look upon the processing plants not only as an outlet for their culls, but as a new market for both the packhouse culls and tree-run fruit. Packhouse culls are sound apples but are lacking in color or other desirable fresh fruit characteristics.

The processors were now assured of a more dependable supply of higher quality apples. In 1930, to avoid confusion between growers and processors, U.S.D.A. Grades for Apples for Processing were established; they were accepted by both producers and processors. The following are pertinent excerpts taken from the present U. S. Standards for Apples for Processing *(2)*:

> "U. S. No. 1 apples shall be free from any defect which cannot be removed during the usual commercial preparation for use without causing a loss of over 5 per cent, by weight, of the apples in excess of that which would occur if the apples were perfect.
>
> U. S. No. 2 apples shall be free from any defect which cannot be removed during the usual commercial preparation for use without causing a loss of over 25 per cent, by weight, of the apples in excess of that which would occur if the apples were perfect.
>
> Culls shall consist of apples which do not meet the requirements of either of the foregoing grades."

The U.S.D.A. Grades have served the apple processing industry well during a period of great growth.

The usual processing procedure employed by the industry in the Appalachian area consists basically of the following operations. A blend of desirable varieties is mechanically washed, sorted, sized, peeled and cored, trimmed by hand, and inspected. Trim-

ming by hand is done for the purpose of taking out peel not removed by mechanical peelers and to remove defects caused by insects, diseases, bruising, and other physical injuries. The inspected apples are cooked under steam pressure, mixed with sugar and finished in a paddle type finisher. The sauce must be reheated prior to filling cans or glass jars; the filling temperature is therefore usually 180° F. (82.2° C.) or somewhat higher to assure safekeeping. After filling and closing, and after a suitable holding period, the containers are water cooled to an average temperature of 100° F. (37.8° C.).

Because the cost of raw product to the processors has increased, as well as other costs such as capital investment, overhead, and operating cost, processors have had to evaluate more critically all factors that affect production of finished products. The purpose of this study is to evaluate the factors which affect time and recovery of various fractions in the peeling and trimming operations of apples and their relationship to each other. The fractions considered are: peels and cores; trim waste; prepared apples (peeled, cored, and trimmed apples). The three fractions mentioned above never add up to 100%. There is usually a difference of about 1 to 2% which is generally referred to as "spatter" or unaccountable waste. Trim waste is that waste which results when defects and peel, left after mechanical peeling, are removed. This operation is done by hand. The time spent in the peeling and trimming operations is important because it affects production costs.

Raw products factors of greatest concern to the processing industry are: Size, quality (grade), variety, per cent yield of product, maturity, flavor, color of flesh, and firmness. This study is concerned with the first four of these factors and with the time spent in performing the peeling and trimming operations. The processing industry is interested in the relationships and inter-relationships among the four factors mentioned above because they have a direct bearing upon cost. The fruit growers are interested because the processors pay them on the basis of these factors. It should be mentioned that a review of the literature has been made, but no information pertinent to the subject of this paper has been found.

EXPERIMENTAL

Experiment I. The experiment was conducted during the 1954 and 1955 processing seasons. The fruit used in this experiment was of the four more common processing varieties in the Appalachian area: York Imperial, Golden Delicious, Stayman, and Grimes Golden. Recovery data were taken for each variety separately. A complete and separate experiment was run in each of three applesauce processing plants, all located in Virginia.

Apples of one variety, of maturity usually regarded as optimum for processing, were taken either from cold storage, from grower packhouses, or from the processing plant production line. The apples were sized into three sizes, 2¼ in. to 2½ in., 2½ in. to 2¾ in. and up in diameter. The apples in each size were graded by Federal-State fresh fruit inspectors into U. S. No. 1 and U. S. No. 2 apples, using the U.S.D.A. Grades of Apples for Processing. Culls were not used for the work reported here. There were, then, 6 different grade-size classifications. After grading, the apples were held in cold storage (32° F., 0° C.) until processed. The holding time was not more than one week in any one case. From one to 20 samples weighing approximately 40 lbs. each were prepared for each grade-size classification in each plant, depending upon the availability of the different sizes and grades of fruit. Four varieties of apples were sampled in the 3 processing plants. Each one of these 40 lb. samples was run separately through a mechanical peeler-corer operated by the plant being studied. The peelers used were F. B. Pease units. In one of the plants a one-cup peeler was used, while in the other 2 plants, the peelers were of the 3-cup type. The peeled and cored fruit was trimmed by personnel regularly working on the production line, but transferred temporarily to the experimental machine. Records were made of (1) the weight of the peel and core waste; (2) total trim waste; (3) the weight of the whole peeled, cored, and trimmed apples; and (4) the time required to trim each sample.

Experiment II. Because of some question as to the validity of a 40 lb. sample being representative of commercial conditions in time and recovery studies, and because certain refinements in measuring recovery were indicated from analysis of the 40 lb. sample data, it was felt desirable to perform a second experiment under commercial conditions as a check against the first experiment and to answer other questions raised by the industry since the beginning of the first experiment.

Four Virginia and Pennsylvania processors[a] agreed to cooperate with the Virginia Agricultural Experiment Station in running pre-graded and pre-sized lots of apples through their regular production line during the 1956 processing season. In 2 of the 4 plants two 4-cup F. B. Pease peelers were employed. The apples were obtained from growers that usually supply fruit to the plant at which the work was to be done. Apples of the York Imperial variety[b] and of maturity considered optimum for processing were used.

On the basis of previous experience (Experiment I), the size of the lots was adjusted so that each lot would require approximately 45 to 60 minutes of plant operation. Three size classifications of U. S. No. 1 and U. S. No. 2 grades (2¼ in. to 2½ in., 2½ in. to 2¾ in., and 2¾ in. and up in diameter) were run in each plant. The fruit was graded by Federal-State fresh fruit inspectors. The weight of the sample run for each lot (grade-size classification) ranged from 1000 to 4000 lbs.

For this experiment, apples in each lot were weighed and automatically counted as they were peeled. The peeling, coring, and trimming time was recorded. Peels and cores (mechanical waste), the trimmings, and the peeled, cored, and trimmed apples were weighed separately. Also a 15-lb. sample was taken from the trim waste that was produced by each size and grade classification. The defect trim and the peel trim of this 15-lb. sample were separated and weighed in order to determine the proportion of defect trim and of peel trim in the total trim.

Although all of the cooperating plants used the same make of mechanical peelers, there was considerable variation in the ways the machines were adjusted at the various plants. One plant would adjust the peeling knife deep enough to remove some defects, along with the peel, whereas another plant would remove only the skin of the apples and depend upon the trimmers to remove the defects by hand trimming. Other variations also occurred between plants which made direct comparisons of results invalid. The statistical methods used in the analysis of results allow for plant-to-plant differences resultitng from unmeasured factors when determining relationships between the factors measured.

RESULTS AND DISCUSSION

Table 1 shows time and recovery data for Experiment I. There were no significant differences among varieties for yield of prepared apples, peel and core

[a] Different codes have been used for each processing plant throughout the text in order to make plant identification impossible.

[b] In some plants a very small proportion of other varieties was included, as this was the commercial practice in the plants.

waste, or trim waste for apples of Grade U. S. No. 1 for Processing. The larger sizes of apples of all varieties yielded a greater percentage of prepared product than the smaller sizes. Also, apples of all varieties of Grade U. S. No. 1 for Processing yielded more prepared product than fruit of Grade U. S. No. 2. The amount of peel and core removed as a per cent of weight of fresh fruit increased as size decreased and also showed a tendency to increase with declining quality. In apples of Grade U. S. No. 2, a significant difference in amount of trim removed is shown for the four different varieties. In order of the amount of trim taken from the apples, the varieties ranked as follows: Grimes Golden with the least amount of trim, followed by York Imperial, Golden Delicious, and Stayman. These results are consistent with commercial experience. Stayman and Golden Delicious apples bruise more easily because their tissue cells are larger and the cell walls more fragile.

The average amount of total trim waste for apples of Grade U. S. No. 1 for Processing ranged from 3.1 to 6.3% for the 3 sizes. For fruit of Grade U. S. No. 2, average total trim waste ranged from 9.2 to 17.6%.

Time requirements for trimming a given weight of apples of larger size were significantly less than for smaller sized apples and trimming time requirements increased significantly for apples having higher trim removed. York Imperial apples, with comparable trim removed, required significantly longer to trim than apples of the other varieties. This was probably due to the firmer flesh and unsymmetrical shape of the York Imperial variety, which made trimming more difficult.

The above observations are considered valid even though the trimming times obtained in Experiment I are not considered representative of actual commercial conditions. Because of the short time required to peel and trim the 40 lb. samples, with a clean-up period intervening between samples, and the fact that the workers doing the trimming were not working with others in the production line, the time for all lots is somewhat higher than under production line conditions. Also, trimming time differences between sizes and qualities may be somewhat understated because all of the sample was peeled without reference to the time required to trim, whereas under production line conditions the peelers usually peeled only as fast as the trimmers could trim.

Table 2 shows time and recovery data for Experiment II. The general observations that may be made concerning Table 2 are exactly the same as those that were made concerning Table 1 from Experiment I. As noted in discussing Table 1, the differences in trimming time required for size classes and quality classes are higher than in Experiment I.

Figure 1 presents actual plant data from the experimental lots showing the proportion of total trim waste made up of defect trim and of peel trim respectively. In no case was the defect trim fraction of total trim from U. S. No. 1 apples as high as the maximum tolerance allowed for defect trim in the grade. Only occasionally was the total trim up to the tolerance for defect trim alone. In only four instances out of twelve were defect trim removals in the U. S. No. 2 grade up to the maximum tolerance in the U. S. No. 1 grade.

As mentioned previously, differences existing among plants make direct comparisons of plant data invalid. However, the method followed in Experiment II was too expensive to allow the replication of samples needed in order to analyze each plant's data separately. Therefore, a statistical method of covariance analysis, known as differential contrast [Anderson *(1)*], has been used. This method allows pooling of observations from all plants in determining, by regression, relationships between the continuous variables, while accounting for variability among plants caused by discrete and unmeasured variables. The authors utilized these statistical methods using the data obtained at the processing plants to develop the equations that follow.

Figure 2 shows the effect that size of apples had on (a) per cent peels and cores, and (b) per cent recovery of prepared product (peeled, cored, and trimmed apples), as found in four applesauce processing plants. In order to show only the effect of size of apples on the two dependent fractions, the per cent trim waste was held constant for all plants in all size classes at the average of the 4 plants, even though the level of trim waste varied widely between plants.

The difference in yield among plants resulted from differences in intercepts and per cent peels and cores among plants. Variations in peels and cores resulting from differences in policy in regard to type of knives used in peeling and thickness of peel removed was the greatest cause of variation in yield among plants. Some plant managers have the apples peeled quite heavily to remove some of the defects along with the peel while others peel lightly and depend on trimmers to remove defects. Some peeling machines were equipped with knives that removed peels from the calyx and stem end of the apples; others were not equipped to do this. Differences in core size removed in different size classes of apples also varied among plants.

In the samples of apples from the 4 plants upon which Figure 2 is based, apples of size 2¾ in. and up in diameter averaged 263 apples per 100 lbs., apples in size class 2½ in. to 2¾ in. in diameter averaged 424 apples per 100 lbs., and apples in size class 2¼ in. to 2½ in. in diameter averaged 530 apples per 100 lbs. The values in Figure 2 are based on the following two regression equations:

$$\hat{Y} = 19.30 + P_B + P_C + P_D + 0.0262\ X_1 + 0.3088\ X_2, \quad (1)$$

where:

$\hat{Y}$ = Per cent peels and cores
P_i = Plant (P_A is included in the intercept)
X_1 = Number of apples per 100 lbs. of fresh fruit
X_2 = Per cent total trim waste

$$\hat{Y} = 99.74 + P_B + P_C + P_D - 1.077\ X_1 - 1.1396 X_2 \quad (2)$$

where:

$\hat{Y}$ = Per cent yield of prepared product
P_i = Plant (P_A is included in the intercept)

TABLE 1

Average time and recovery values[1] for processing applesauce from different sizes and grades of York Imperial, Grimes Golden, Stayman, and Golden Delicious varieties of apples

Variety: York Imperial

	Grade U. S. 1						Grade U. S. 2					
	2¼"–2½"		2½"–2¾"		2¾" and Up		2¼"–2½"		2½"–2¾"		2¾" and Up	
Number of approx. 40-lb. samples run in each of three processing plants	10, 13, & 13		9, 4, & 18		10, 15, & 24		4, 1, & 6		10, 2, & 6		17, 7, & 11	
Prepared[2] Apples (per cent[3])	69.0[4]	.94[5]	72.5	.99	73.6	1.00	61.3	.83	65.5	.89	66.0	.90
Peels and Cores (per cent[3])		1.17	21.7	1.04	20.8	1.00	28.1	1.35	23.6	1.13	21.3	1.02
Total Trim[6] (per cent[3])	6.3	1.21	5.4	1.04	5.2	1.00	10.3	1.98	10.5	2.01	12.3	2.36
Total Waste (per cent[3])		1.18	27.1	1.04	26.0	1.00	38.4	1.48	34.2	1.32	33.6	1.29
Number of Apples Per 100 lbs. of Fresh Fruit	30.6 514	2.12	383	1.58	243	1.00	507	2.09	381	1.57	260	1.07
Trimming Time[7] per 100 lbs. of of Fresh Fruit (minutes)	28.5	1.02	26.5	.95	27.9	1.00	47.8	1.71	43.1	1.54	42.3	1.52
Trimming Time[7] per 100 lbs. of Prepared[2] Apples (minutes)	41.3	1.09	36.6	.97	37.9	1.00	78.0	2.06	65.8	1.74	64.1	1.69

Variety: Golden Delicious

Number of approx. 40-lb. samples run in each of two processing plants	10 & 12		1 & 10		10 & 18		8 & 9		6 & 10		9 & 8	
Prepared[2] Apples (per cent[3])	69.8[4]	.94[5]	68.8	.93	74.2	1.00	59.5	.80	61.3	.83	65.2	.88
Peels and Cores (per cent[3])	24.5	1.13	26.9	1.24	21.7	1.00	24.9	1.15	24.7	1.14	22.4	1.03
Total Trim[6] (per cent[3])	5.6	1.47	4.2	1.11	3.8	1.00	15.0	3.94	13.7	3.60	12.2	3.21
Total Waste (per cent[3])	30.1	1.18	31.1	1.22	25.5	1.00	39.9	1.56	38.4	1.51	34.6	1.36
Number of Apples Per 100 lbs. of Fresh Fruit	490	1.79	403	1.47	274	1.00	498	1.82	399	1.46	288	1.05
Trimming Time[7] per 100 lbs. of of Fresh Fruit (minutes)	19.8	1.08	21.4	1.16	18.4	1.00	36.8	2.00	35.8	1.95	29.9	1.63
Trimming Time[7] per 100 lbs. of Prepared[2] Apples (minutes)	28.4	1.15	31.1	1.25	24.8	1.00	61.8	2.49	58.4	2.35	45.9	1.85

Variety: Grimes Golden

Number of approx. 40-lb. samples run in each of two processing plants	4 & 9		9 & 11		9 & 21		18 & 9		27 & 6		19 & 14	
Prepared[2] Apples (per cent[3])	68.6[4]	.91[5]	73.1	.97	75.5	1.00	61.0	.81	67.2	.89	68.0	.90
Peels and Cores (per cent)	26.3	1.24	22.7	1.07	21.2	1.00	28.4	1.34	23.3	1.10	21.3	1.00
Total Trim[6] (per cent)	4.8	1.55	4.0	1.29	3.1	1.00	10.2	3.30	9.2	2.97	10.4	3.35
Total Waste (per cent)	31.1	1.28	26.7	1.10	24.3	1.00	38.6	1.59	32.5	1.34	31.7	1.30
Number of Apples per 100 lbs. of Fresh Fruit	527	1.84	390	1.36	287	1.00	501	1.75	383	1.33	279	.97
Trimming Time[7] per 100 lbs. of of Fresh Fruit (minutes)	22.5	1.22	18.7	1.01	18.5	1.00	35.7	1.93	30.8	1.66	32.4	1.75
Trimming Time[7] per 100 lbs. of Prepared[2] Apples (minutes)	32.8	1.34	25.6	1.04	24.5	1.00	58.5	2.39	45.8	1.87	47.6	1.94

Variety: Stayman

Number of approx. 40-lb. samples run in each of two processing plants	13 & 18		10 & 10		12 & 22		9 & 9		12 & 8		10 & 16	
Prepared[2] Apples (per cent[3])	65.7[4]	.90[5]	69.8	.95	73.4	1.00	53.0	.72	59.6	.81	60.0	.82
Peels and Cores (per cent)	28.6	1.29	24.0	1.09	22.1	1.00	30.1	1.36	24.4	1.10	22.0	1.00
Total Trim[6] (per cent)	5.1	1.24	5.7	1.39	4.1	1.00	16.2	3.95	15.5	3.78	17.6	4.29
Total Waste (per cent)	33.7	1.29	29.7	1.13	26.2	1.00	46.3	1.78	39.8	1.52	39.6	1.51
Number of Apples per 100 lbs. of Fresh Fruit	488	1.91	378	1.48	256	1.00	497	1.94	402	1.57	258	1.01
Trimming Time[7] per 100 lbs. of of Fresh Fruit (minutes)	26.7	1.07	24.2	.97	24.9	1.00	44.2	1.78	38.6	1.55	41.3	1.66
Trimming Time[7] per 100 lbs. of Prepared[2] Apples (minutes)	40.6	1.20	34.7	1.02	33.9	1.00	83.4	2.46	64.8	1.91	68.8	2.03

[1] All values are weighted based on number of samples run in each plant.
[2] Prepared apples are peeled, cored, and trimmed apples.
[3] Per cent of fresh fruit.
[4] Actual values obtained in experimental work.
[5] Ratio of value found to value for size 2¾" and Up in Grade U.
[6] Total trim is that waste that results when defects and peel left after mechanical peeling are removed.
[7] Time is expressed as minutes required by one worker.

X_1 = Per cent peels and cores
X_2 = Per cent total trim

Equation 1 explains 90% of the total squared variation of peels and cores about the mean in the experimental samples. The regression values for X_1 and X_2 are significant at the 95% level or better, and explain 75% of the total squared variation about the mean in the samples unexplained by differences between plants. The per cent peels and cores as used in Equation 2 is adjusted for variation due to number of apples per 100 lbs. of fresh fruit and per cent total trim waste. Equation 2 explains 87% of the total squared variation about the mean of per cent yield in the samples. The regression values for X_1 and X_2 are significant at the 99% level. The two continuous variables, X_1 and X_2 explain 80.5% of the total squared variation about the mean in the samples for yield unexplained by plant differences.

Figure 3 shows the effect of grade and of size on total trim waste as observed in the 4 plants. Total trim removed from U. S. No. 1 grade apples was from 56 to 59% of the total trim removed from U. S. No. 2 grade apples when results from the 4 plants were

TABLE 2

Time and recovery values for processing applesauce from the York Imperial variety[1] of apples. Average values from four processing plants

	U. S. No. 1						U. S. No. 2					
	2¼"–2½"		2½"–2¾"		2¾" and Up		2¼"–2½"		2½"–2¾"		2¾" and Up	
Prepared[2] Apples (per cent[3])	64.4 ± 3.6[4]	.88[5]	67.2 ± 3.2	.92	72.8 ± 3.5	1.00	58.6 ± 3.0	.80	60.7 ± 3.7	.83	66.7 ± 3.1	.92
Peels and Cores (per cent)	29.7 ± 3.4	1.36	27.2 ± 2.6	1.25	21.8 ± 3.0	1.00	31.0 ± 4.4	1.42	29.0 ± 4.5	1.33	25.0 ± 3.1	1.15
Total Trim (per cent)	4.2 ± 1.2	1.17	3.8 ± 1.5	1.06	3.6 ± .8	1.00	6.7 ± 1.8	1.86	7.2 ± 1.4	2.00	6.8 ± 1.1	1.89
Total Waste (per cent)	33.9 ± 3.3	1.33	31.0 ± 3.3	1.22	25.4 ± 3.6	1.00	37.7 ± 4.0	1.48	36.2 ± 3.7	1.43	31.8 ± 3.8	1.25
Unaccountable Waste (per cent)	1.7 ± .4	.94	1.8 ± .8	1.00	1.8 ± .6	1.00	3.8 ± 1.5	2.11	3.1 ± 1.2	1.72	1.5 ± .6	.83
Number of Apples per 100 lbs. of Fresh Fruit	530 ± 4.5	2.01	424 ± 11.5	1.61	264 ± 19.2	1.00	510 ± 13.2	1.93	412 ± 15.2	1.56	284 ± 31.5	1.08
Trimming Time per 100 lbs. of Fresh Fruit (minutes)[6]	31.8 ± 4.6	1.48	25.6 ± 3.2	1.19	21.5 ± 5.1	1.00	37.7 ± 6.7	1.75	36.0 ± 4.7	1.67	30.0 ± 6.0	1.39
Trimming Time per 100 lbs. of Prepared Apples (minutes)[6]	49.3 ± 6.4	1.65	38.2 ± 4.3	1.28	29.9 ± 8.2	1.00	64.7 ± 13.6	2.16	59.2 ± 8.6	1.98	45.5 ± 10.2	1.52
Average Quantity of Fresh Apples Used at Each Plant	6,610 lbs.		8,378 lbs.		12,911 lbs.		4,725 lbs.		5,921 lbs.		9,555 lbs.	

[1] A small per cent of apples of other varieties were included.
[2] Prepared apples are peeled, cored, and trimmed apples.
[3] Per cent of fresh fruit.
[4] Average deviation.
[5] Ratio of value found to value for size 2¾" and Up in Grade U. S. No. 1.
[6] Time is expressed as minutes required by one worker.

averaged. The range between plants and sizes of apples was from 47% in Plant A for apples 2¾ in. and up in diameter to 68% in Plant B for apples 2¼ in. to 2½ in. in diameter. In all plants the ratio of per cent trim from U. S. No. 1 apples to per cent trim from U. S. No. 2 apples became less as apple size increased. This was because the peel fraction of total trim was higher in the small apples in both U. S. No. 1 and U. S. No. 2 grades and was a larger proportion of the total trim in the U. S. No. 1 grade.

Values in Figure 3 are based on the regression equation:

$$\hat{Y} = 4.01 + P_B + P_C + P_D + G_2 - 0.2049\ X_1 + 0.0086\ X_2 + 0.0239\ X_3, \quad (3)$$

where:

$\hat{Y}$ = Per cent total trim
P_i = Plant (P_A is included in the intercept)
G_1 = Grade (G_1 is included in the intercept)
X_1 = Per cent peels and cores
X_2 = Number of apples per 100 lbs. of fresh fruit
X_3 = Per cent of total trim due to defect removal

The regression equation explains 86% of the total squared variation about the mean of per cent total trim in the experimental samples. The 3 regression coefficients for X_1, X_2, and X_3 are significant at the 95% level or better. Plant differences explain 30%, grade differences explain 51%, and the three continuous variables explain 5% of the total squared variation about the mean of the sample in total trim waste. In calculating the values for the 4 plants in Figure 3, the individual plant values for X_1, X_2, and X_3 were used. The level of trim for the different plants varied widely, as was explained in discussing Figure 1, and also because of plant policy in removal of defects and peel left on the apples after peeling.

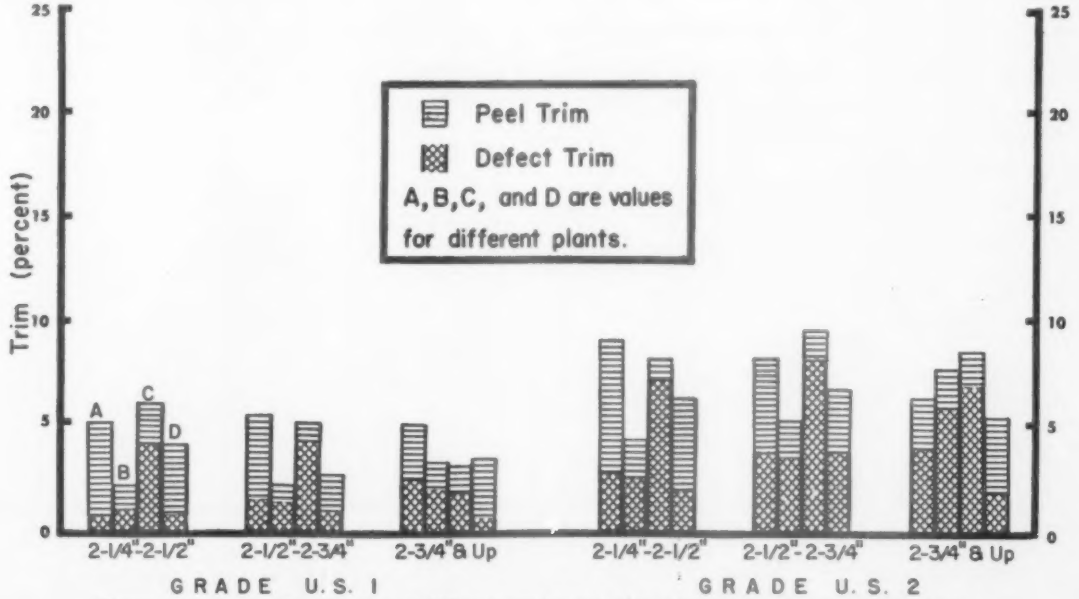

Figure 1. Per cent trim of apples of different grades and sizes observed at four processing plants.

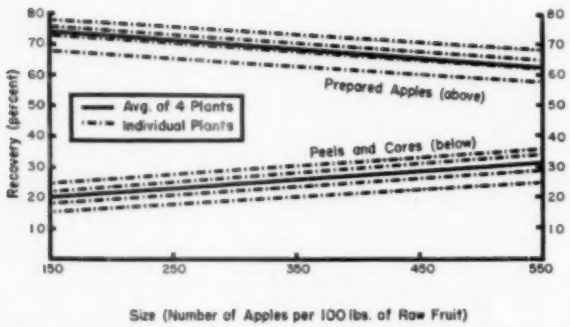
Recovery (percent)
Avg. of 4 Plants
Individual Plants
Prepared Apples (above)
Peels and Cores (below)
Size (Number of Apples per 100 lbs. of Raw Fruit)

Figure 2. Effect of size of apples on per cent recovery of prepared apples and of peels and cores.

Figure 4 shows the effect of grade and of size on trimming time as observed in 4 processing plants. Grade is measured by total trim waste and per cent of total trim due to defect removal. The 4 plants, on the average, took from 24 to 48% longer time to trim apples in the U. S. No. 2 grade than in the U. S. No. 1 grade. This variation among plants ranged from 23% in Plant C for apples 2¼ in. to 2½ in. in diameter, to 59% in Plant D for apples 2¾ in. and up in diameter. Size and grade were of approximately equal importance in affecting trimming time in these 4 plants for the experimental samples.

Figure 4 values for trimming time were based on the regression equation:

$$\hat{Y} = -4.32 + P_B + P_C + P_D + 2.1404\ X_1 + 0.0378\ X_2 + 0.0815\ X_3, \qquad (4)$$

where:

$\hat{Y}$ = Minutes to trim 100 lbs. of fresh fruit
P_I = Plant (P_A is included in the intercept)
X_1 = Per cent total trim waste
X_2 = Number of apples per 100 lbs. of fresh fruit
X_3 = Per cent of total trim due to defect removed

In calculating the individual plant values, the individual plant experimental sample values for X_1, X_2, and X_3 were used in the regression equation. This equation accounts for 92% of the total squared variation in trimming time about the mean in the experimental samples. All regression coefficients are significant at the 99% level. The three continuous variables, X_1, X_2, and X_3 account for 77% of the total squared variation in trimming time about the mean that was unaccounted for by plant differences.

Figures 5 and 6 show the effect of trim due to defects on time required to trim apples. In Figure 5 this effect is shown as an average in 4 plants for 3 size classifications, 530, 424, and 263 apples per 100 lbs. of fresh fruit, representing size classes 2¼ in. to 2½ in., 2½ in. to 2¾ in., and 2¾ in. and up in diameter respectively. Figure 6 shows the relationship of this effect among plants at one size level. The size used in this figure is the average size of all apples used in the 4 plants.

Both Figure 5 and Figure 6 are based on Equation 4, used also to derive the values for Figure 4. These figures are shown in addition to Figure 4 in order to show more explicitly the extent of the effect of the defect trim fraction of total trim on trimming time. It can be seen in these figures that 1% defect trim causes trimming time to be increased approximately by 2.5 minutes per 100 lbs. of fresh fruit. A separate analysis using defect trim and peel trim as separate independent factors in affecting trimming time showed that defect trim affected trimming time about twice as much as did peel trim.

In Figure 5, the line representing apples 2¾ in.

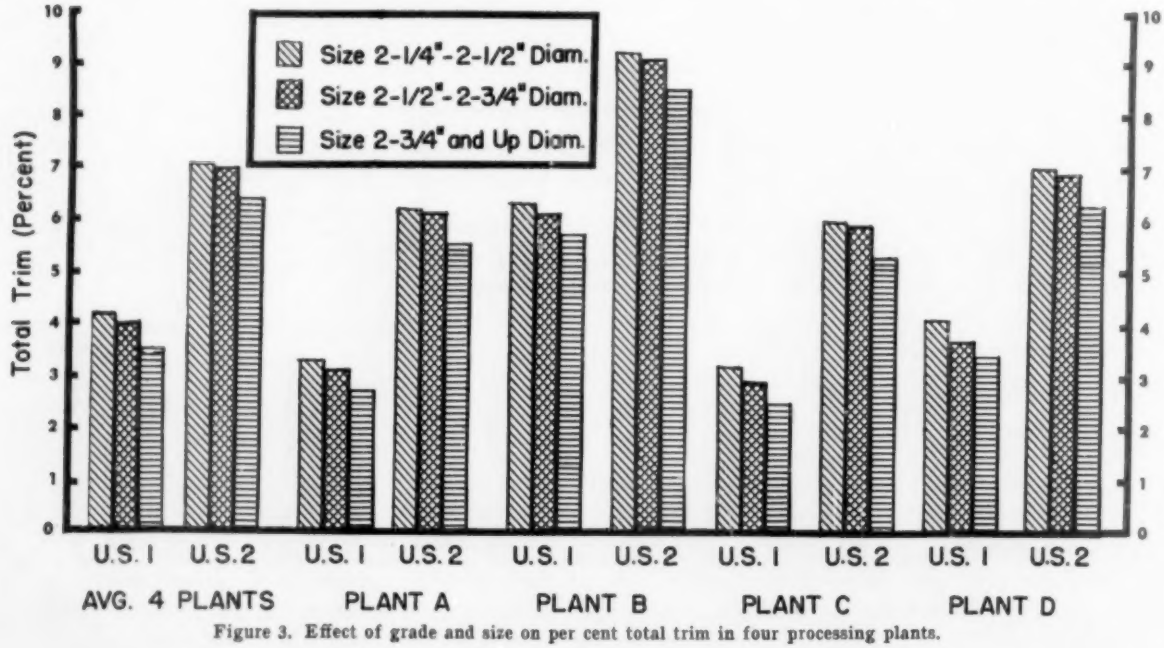

Figure 3. Effect of grade and size on per cent total trim in four processing plants.

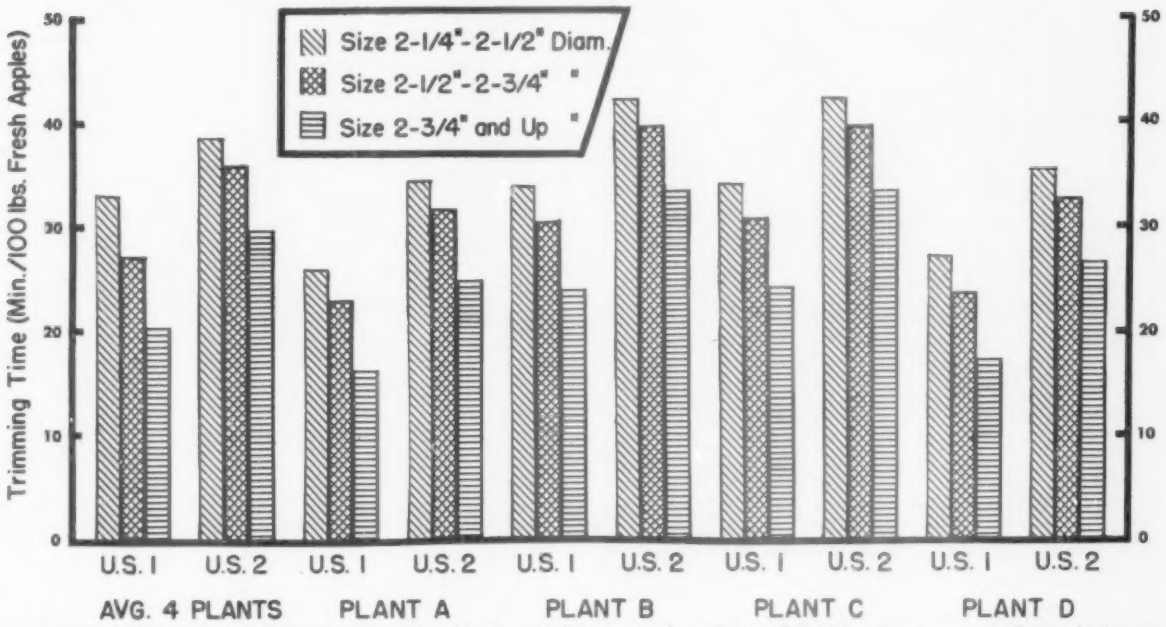

Figure 4. Effect of grade and of size on trimming time in four processing plants. Trimming time is expressed as minutes required by one worker.

and up in diameter lies approximately 6.75 minutes below the line representing apples 2½ in. to 2¾ in. in diameter. The line representing apples 2¼ in. to 2½ in. in diameter lies only 4.5 minutes above the line for apples 2½ in. to 2¾ in. in diameter. The difference between the lines is due to differences in both per cent peel trim and per cent defect trim. The trim due to defects was greater with the larger size apples, but the total trim was somewhat lower with the large size.

In Figure 6 the difference between the lines representing the different plants is due to intercept differences between plants as previously explained and to differences in total trim and in defect trim. The per cent defect trim was greater in the plants having lower time requirements but the total trim removed was less in these plants.

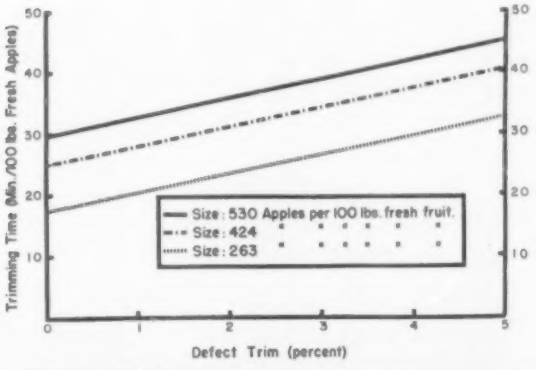

Figure 5. Relationship between defect trim and trimming time for apples of different sizes. Trimming time is expressed as minutes required by one worker.

Because of difference in cost of experimental work involved in Experiments I and II, a comparison of results obtained by the two methods seemed desirable. Data on the factors affecting recovery and time from Experiment I were substituted into Equations 1 and 2 derived from Experiment II to determine the degree of correspondence between estimated and actual values for Experiment I. Results of these comparisons are shown in Tables 3 and 4.

Estimated recovery of prepared product is close to the yield obtained in Experiment I. There is a slight tendency for the yield values to be overestimated for grade U. S. No. 1 apples and to be underestimated for U. S. No. 2 apples. Estimated values for recovery of peels and cores are in all cases slightly larger than the actual values.

Estimated trimming time in Table 4 does not correspond as closely to the actual values of Experiment I as do the estimated values for yield of prepared product and peels and cores in Table 3. This lack of correspondence was expected in regard to trimming time because of the non-commercial conditions under which the 40-lb. samples in Experiment I were trimmed. (See paragraph 4, Results and Discussion).

Results of the comparisons indicate essentially equal results in yield determination from Experiment I and Experiment II. Although general relationships for trimming time are the same for Experiment I and Experiment II, the quantitative time values for Experiment I are not representative of commercial conditions. If yield and only general time relationships are desired, they can be obtained by Experiment I methods at less cost. However, if comparative time studies are to be made, Experiment II methods will produce more reliable results.

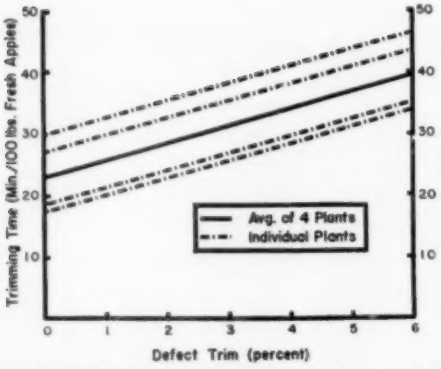

Figure 6. Relationship between defect trim and trimming time observed at four processing plants. Trimming time is expressed as minutes required by one worker.

A paper dealing with a more detailed explanation of the statistical methods, statistical significance, and the applications of the results of the relationships developed in this study to price differentials between grades and sizes is being prepared.

SUMMARY AND CONCLUSIONS

The purpose of this study was to evaluate the factors which affect time and recovery of various fractions in the peeling and trimming operations of apples and their relationships to each other.

Alternative methods were compared as to their suitability in giving reliable results in time and recovery. The yield data resulting from Experiment I was essentially the same as that from Experiment II and can be obtained with less cost. Methods followed in Experiment I are not suitable for comparative time studies.

No significant difference was found among the four varieties for yield of prepared apples and of peel and core waste. Varietal differences were found for U. S. No. 2 apples in per cent trim waste. Trimming time increased as size decreased and as total trim increased. The York Imperial variety required longer to trim than the apples of three other varieties. Variations in peels and cores and in total trim waste were the greatest cause for variations in yield of product. Because of the relationship of size of apples with both peel and core waste and total trim waste, size was a more important factor affecting yield than was grade. Variations in grade and in size have about equal effect on trimming time. One per cent increase in defect trim resulted in approximately 2.5 minutes increase in trimming time for 100 lbs. of apples of any size. Trim resulting from removal of defects had nearly double the effect on trimming time than trim resulting from peel removal.

The estimating equations developed in this study from methods used in Experiment II may be used in applesauce processing plants for determining differential costs of peeling and trimming apples of different size and quality.

TABLE 3

Comparison of recovery values obtained from Experiment I with recovery values estimated by equations derived from Experiment II

	Per cent recovery of product			Per cent peels and cores		
	Actual	Estimated	Difference	Actual	Estimated	Difference
Grade U.S. No. 1:						
Size 2¼"–2½"	67.0	67.6	+0.6	30.0	31.4	+1.4
Size 2½"–2¾"	70.0	70.4	+0.4	26.7	28.4	+1.7
Size 2¾" and Up	71.0	71.5	+0.5	24.1	26.1	+2.0
Grade U.S. No. 2:						
Size 2¼"–2½"	60.9	60.7	−0.2	30.4	33.2	+2.8
Size 2½"–2¾"	61.4	60.9	−0.5	27.2	30.0	+2.8
Size 2¾" and Up	62.5	62.1	−0.4	24.6	28.4	+3.8

TABLE 4

Comparison of trimming time values obtained from Experiment I with trimming time values estimated by equations derived from Experiment II

	Trimming time (Minutes per 100 lbs. of fresh apples)		
	Actual	Estimated	Difference
Grade U.S. No. 1:			
Size 2¼"–2½"	31.6	29.4	−2.2
Size 2½"–2¾"	25.7	26.4	+0.7
Size 2¾" and Up	30.3	25.6	−4.7
Grade U. S. No. 2:			
Size 2¼"–2½"	49.1	42.6	−6.5
Size 2½"–2¾"	45.8	44.3	−1.5
Size 2¾" and Up	42.2	43.2	+1.0

Acknowledgments

The authors wish to express their thanks to the following companies for their interest and cooperation: Bowman Apple Products Company, Inc., Mount Jackson, Virginia; Knouse Foods Cooperative, Inc., Peach Glen, Pennsylvania; The C. H. Musselman Company, Inc., Biglerville, Pennsylvania; National Fruit Product Company, Inc., Shenandoah Valley Apple Cider and Vinegar Corp., and The Zeropack Company, of Winchester, Virginia. The cooperation of the following individuals and companies is also appreciated: Mr. J. H. Henley, Virginia State Apple and Peach Inspection Supervisor; Mr. Jack Shill, Chief Apple and Peach Inspector, Winchester Area, Virginia; Mr. D. K. Russell, apple grower of Clearbrook, Virginia; Hearty-Virginia, Inc., Mount Jackson, Virginia; Mr. Roy E. Moser, Jr., of the Virginia Agricultural Extension Service; and Dr. Ralph G. Kline, of the Virginia Agricultural Experiment Station.

LITERATURE CITED

1. Anderson, R. L. The use of regression techniques with economic data. *Proc.* Auburn Conference on Statistics Applied to Research in the Social Sciences, Plant Sciences, and Animal Sciences, September 7–9, 1948.
2. United States Department of Agriculture, Production and Marketing Administration. U. S. Standards for Apples for Processing. Effective September 2, 1946.

Erratum. *Food Technology*, 11, 488 (1957).

In the article by Nicholas, Pflug, and Costilow, relating to fresh-packed pickle products, the sentence beginning at line 6, page 489, of the paragraph headed pickle-to-liquor ratio should read: An analysis of variance of the data from these 34 jars showed no significant difference in the heating rate, f_h, but a significant difference in the lag factor, j, and a significant difference in the sterilizing value, F160.

If your industry is represented here...
Cheese
Candy
Canning
Baking
Livestock Feeding
Pharmaceuticals
Textile
Rubber
Mining
Water Conditioning
Ceramic
Leather
Soap
Margarine
Meat Packing
Prepared Flours and Mixes
Chemical
Fish
. . . then you will want to know what salt will do for you
No matter what the application, the problem of using salt in industry is highly specialized. Just a few typical applications are described here.
Food Processing and Handling
Butter makers demand quick solubility, and freedom from extraneous matter. They must have the right kind of salt.
Food canners require extreme purity of salt in order to produce maximum flavor, and to protect the tenderness of products such as peas and beans.
For olive and pickle packing, a pure salt minimizes cloudiness or suspended solids in the brine which detract from eye appeal.
In the meat packing industry high purity salt assures mild, uniform flavor. Freedom from impurities reduces precipitation reaction between salt and other pickle cure ingredients.
Bakers want high purity and true salt flavor so they can carry maximum salt for maximum flavor.
Feedmixers, sweeteners, potato chip manufacturers all need uniform bulkiness and mechanical feeding properties.
Textiles
In the textile industry high purity salt is used to replace Glauber's salt (anhydrous sodium sulphate) in neutral dye baths and to replace common salt where calcium-free brines are desirable. The result is a consistently better yield, with less dyestuff required in the dyeing.
Chemicals
In the chemical industry high purity salt means pure chemical reactions in processing. There are no complex side reactions due to the impurities found in common salt.
5

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2) Tendency to retrograde and gel

3) Molecular dispersion

4) Stability against breakdown

5) Transparency

6) Wetting and protective colloid action

Different uses require different properties as, for example, an opaque starch is suitable for salad dressing but a transparent one is more desirable for cherry pie. Films were discussed briefly particularly in textile and paper sizing; desirable features for these industries were summarized.

According to Schoch, modified starches got off to a fast start in the 1800's when a potato starch warehouse in Dublin, Ireland burned down. The starch, which didn't burn, was found to be modified and enhanced in some of its properties. The Irish subsequently found the answer of modification via routes other than those involved in the destruction of warehouses and, thus, a new industry was born.

Much of the material in Dr. Schoch's report may be found in print in the August, 1957 issue of "The Baker's Digest," in an article entitled, "Granule Swelling and Paste Viscosity of Thick Boiling Starches," by Kite, F. E., Schoch, T. J., and Leach, H. W. Reprints may be obtained by writing to Dr. Schoch at Corn Products, Argo, Illinois.

Dr. Schoch received his doctorate degree from Columbia University and has been in starch research since 1929.

—Cora Miller

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MOHAWK VALLEY

The Mohawk Valley was happy to meet and talk with Dr. Emil Mrak, President of the Institute, on November 12. Dr. Mrak gave the group a much needed nudge in the direction of a more active and bigger section. He suggested that we might benefit, as had others, by holding afternoon meetings where there would be opportunity for three or four speakers to treat several phases of a problem of interest.

"The 'Junket' Folks" acted as most gracious hosts at a roast beef dinner at the Mohawk Valley Country Club, Little Falls. A tour through the plant and warehouse of Chr. Hansen's Laboratory, Inc., makers of "Junket" Brand Foods, was made in the afternoon.

Dr. T. F. Irmiter, Laboratory Director of Chr. Hansen's Laboratory, Inc., and President of the section, presented a paper on protein malnutrition which he illustrated with colored slides. The horrible results of undernutrition in children, caused by the lack of protein foods and by not using properly those foods which are available, were vividly shown. Dr. Irmiter indicated that with the aid of food technology, UNICEF, education of the natives along dietetic lines, and helping them to help themselves, much improvement can be made in the nutritional status of protein-starved populations.

—Dorothy Van Schaick

INDIANA

The Indiana section members were the guests of Commercial Solvents Company and the Home Economics Department of Indiana State Teacher's College at Terre Haute on November 8th. Tours of the facilities of these two organizations proved to be most interesting. After dinner, served in the Hoosier Room of the Demming Hotel, Dr. W. P. Allyn, Professor of Biology, Indiana State Teacher's College, spoke to the section on the things students of today value in education and in life.

OPPORTUNITY DAY

To attract high school students into college courses in food technology and related subjects is the objective of the Indiana Section's High School Opportunity Day to be held in Rice Auditorium, Indian-

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apolis, on January 11, 1958. The outstanding success of last year's meeting made this year's meeting an obligation, both from the standpoint of the service that is being rendered high school students pondering career training and from the point of view of bringing food technology as a vocation to the attention of the public. Much effort has been made in recent months to increase interest in scientific training, but it would appear that such effort can be most effectively expended by getting down to the fundamentals; namely, by explaining what scientists, including food scientists, actually do. And this will be an important part of the discussions on High School Opportunity Day, January 11, in Indianapolis.

Opportunity Day has been organized to permit the greatest possible number of direct contacts between visiting representatives from colleges offering training in food technology and the high school students who will be attending the meeting. In addition the Indiana Section is providing movies to pin-point job opportunities, displays, and literature on careers in food technology.

Brief, on-the-beam talks by Dr. Gale R. Ammerman, Food Technologist, Purdue University, Mr. Frank Lawler, Editor, FOOD ENGINEERING, and Dr. Martin S. Peterson, Editor, FOOD TECHNOLOGY, are scheduled. In addition, Miss Judy Ahring, winner of the essay contest run in conjunction with last year's Career Day, will speak.

—William J. Klinker

MINNESOTA

Nine and one-half inches of snow and a Minnesota blizzard were the setting for the November 18th meeting of the Minnesota section of the Institute of Food Technologists.

Dr. Kenneth G. Weckel, professor of Dairy and Food Industries, University of Wisconsin, spoke to the group on a subject of current interest, "Man—Food and Chemicals". As a member of the National Research Council sub-committee on Food Technology, the Technology Committee of the Wisconsin Canners Association, and the Consultant Panel on Milk and Food Research of the U.S. Public Health Service, Dr. Weckel has participated in state and federal committees dealing with the problem of chemicals in foods. Members heard Dr. Weckel describe the rapid growth of the population of the world. In some areas, such as the United States, farm mechanization and scientific agricultural practices have made it possible to keep abreast of domestic demands created by population increases. In the United States this has been accomplished despite a reduction in crop acreage.

Dr. K. G. Weckel addresses Minnesota Section

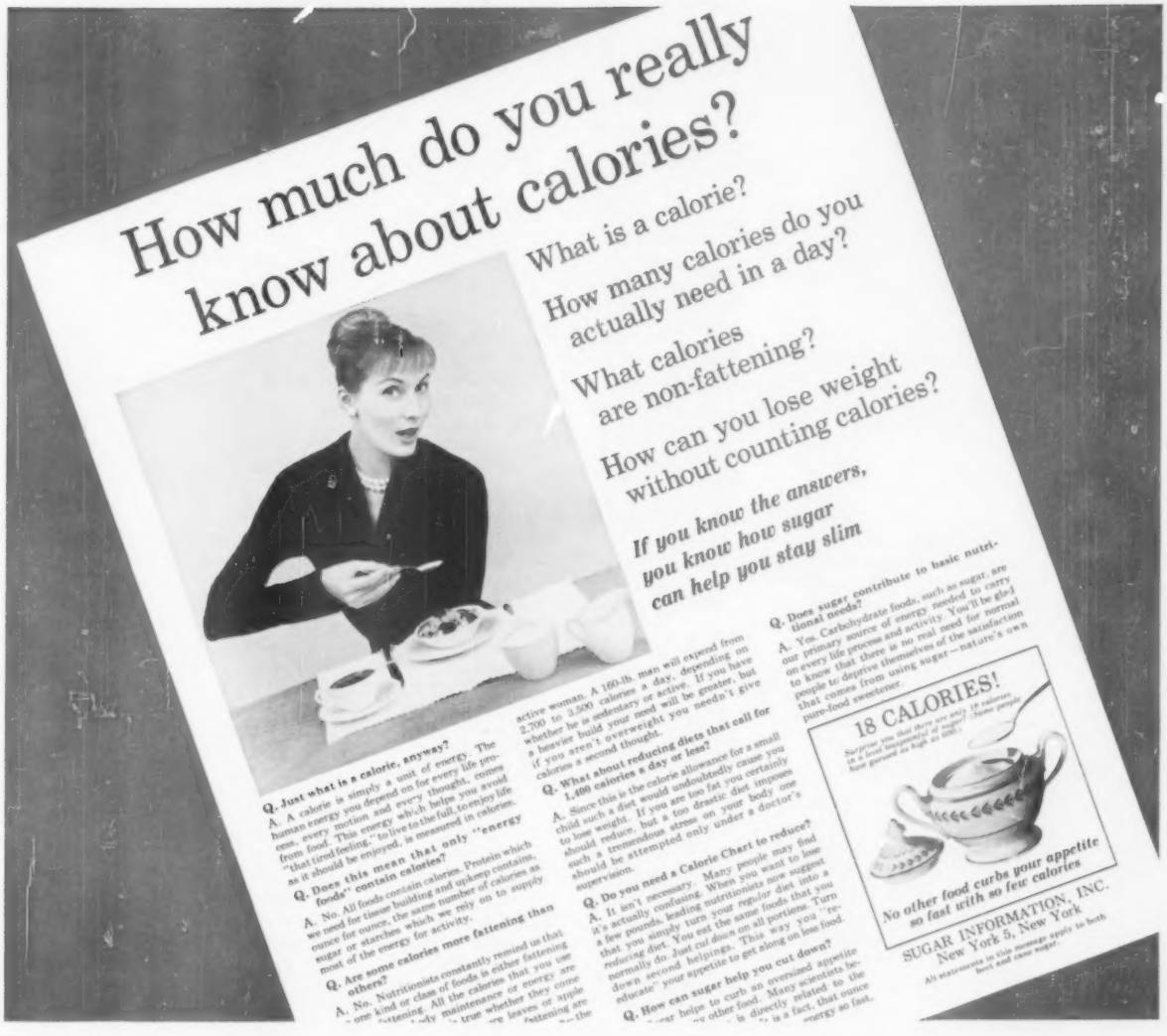
The world, according to Dr. Weckel, faces a potential food shortage in future decades. As a result of this shortage, some areas of the world may have to re-evaluate their positions regarding food additives in order to cope with the situation in a realistic manner.

—Franklin L. Sorensen, Jr.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1958	
January 11	High School Career Day, Sponsored by the Indiana Section of IFT, Rice Auditorium, Indianapolis, Indiana
January 27–30	Plant Maintenance and Engineering Show, International Amphitheater, Chicago, Illinois
February 14–16	Institute of American Poultry Industries 1958 Fact Finding Conference, Municipal Auditorium, Kansas City, Missouri
February 25–26	Sixth Annual National Dairy Engineering Conference, Kellogg Center, Michigan State University, East Lansing, Michigan
March 2–6	Convention of National Association of Frozen Food Packers and Exposition, Conrad Hilton Hotel, Chicago
March 2–9	International Trade Fair of Packaging Machines, Confecionery Machines and Packaging Materials, Dusseldorf, Germany
March 6–8	Annual Meeting of the Refrigeration Research Foundation, Adolphus Hotel, Dallas, Texas
March 14–15	Annual Food Technology Symposium and Short Course, University of Missouri, Columbia, co-sponsored by the St. Louis and the Kansas City Sections of IFT
April 7–11	The American Association of Cereal Chemists, Netherland-Hilton Hotel, Cincinnati, Ohio.
April 22–24	Research and Development Associates, Palmer House, Chicago
May 25–29	**Eighteenth Annual Meeting of the Institute of Food Technologists, Palmer House, Chicago, Illinois**
1959	
May 17–21	**Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadelphia, Pennsylvania**
1960	
May 15–19	**Twentieth Annual Meeting of the Institute of Food Technologists, Civic Auditorium and Hotel Whitcomb, San Francisco, California**
1961	
May 7–11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 17–20	**Twenty-second Annual Meeting of the Institute of Food Technologists, Americana Hotel, Bal Harbor, Miami Beach, Florida**
June 10–13	First International Congress on Vacuum Techniques, Namur, Belgium
June 12–13	First National Convention, Canadian Institute of Food Technology, Windsor Hotel, Montreal. Theme: Canada's Food Industries

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.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What is a calorie?
How many calories do you actually need in a day?
What calories are non-fattening?
How can you lose weight without counting calories?
If you know the answers, you know how sugar can help you stay slim
Q. Just what is a calorie, anyway?
Q. Does this mean that only "energy foods" contain calories?
Q. Are some calories more fattening than others?
Q. What about reducing diets that call for 1,400 calories a day or less?
Q. Do you need a Calorie Chart to reduce?
Q. How can sugar help you cut down?
Q. Does sugar contribute to basic nutritional needs?
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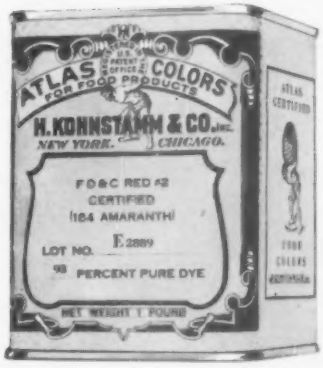

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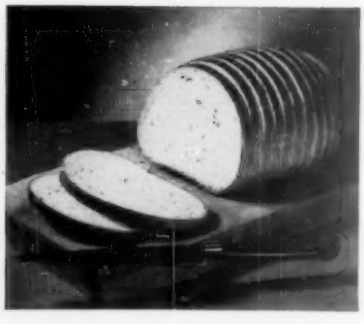

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Literature

BOOKS

STERILIZATION IN FOOD TECHNOLOGY. THEORY, PRACTICE, AND CALCULATIONS. *C. Olin Ball and F.C.W. Olson—McGraw-Hill Book Company — New York, Toronto, London — 654 Pages.*

The authors evidently intended this volume to be "all things to all men," at least to all men who are interested in sterilization of foods. In attempting this, they certainly have accomplished a monumental task. The subject matter ranges from a philosophical discussion of the value of mathematics as a means of solving scientific problems to the presentation of voluminous numerical tables for use in the calculation of thermal processes for canned foods. This book should be available to all organizations dealing with thermal sterilization of foods, and will serve as an excellent reference for students.

Briefly, the subject matter includes: a comprehensive description of methods and equipment for thermal processing (chapter 2); a discussion of the basis of food process calculation methods (chapter 3); bacteriology of food spoilage and sterilization (chapter 4); heat penetration and its measurement (chapter 5); the mathematical and physical basis of heat transfer in closed containers (chapters 6-9); the inoculated pack method of process determination (chapter 10); and methods of process calculation (chapters 11-13). Much of this material has been published elsewhere, but there is considerable convenience in having it collected in one volume and amplified by the authors' comments. Incidentally, they have done a fine job in presenting both sides of controversial issues, such as selection of the criteria for sufficiency of a sterilization process.

Chapter 14, "New Formula Method for Calculating Processes," and chapter 15, "Evaluation of Heat Effect on Organoleptic Quality," presenting new material, will be of interest to all food technologists and warrant detailed study by those specializing in food sterilization. The new formula method of calculation has a number of advantages over the previous methods. The method of evaluation of heat effect on organoleptic quality is an elaboration of a principle that was advanced a number of years ago showing that the temperature coefficient for inactivation of bacteria exceeds that for chemical reactions such as destruction of vitamins; consequently, sterilization can be achieved with a minimum of deleterious effect by employing high temperature-short time processes. Chapter 15 presents formulae and detailed numerical tables for calculating this effect on an averaged basis for the entire contents of a container.

Dr. C. Olin Ball, author, with F. C. W. Olson of "Sterilization in Food Technology."

In general, the book is replete with references and gives considerable detail in both the table of contents and the index. In view of the current interest in the use of ionizing radiations for sterilizing food, it is somewhat surprising to find only two brief references to this subject in the index and no listing of the subject in the rather detailed table of contents. However, the over-all impression is that a great deal of detail has been presented in the book with painstaking accuracy.

J. M. Jackson
Barrington, Illinois

LITERATURE ON FOOD RESEARCH AND TECHNOLOGY [1]

Commodities

XIV International Dairy Congress, Rome, 1956. [Atti.] Rome, Ed. Crea, Centro Realizzazione Editoriali Aristiche, 1956. 6 v. Numerous contributions by contributors from many countries on various aspects of the dairy industry including technological aspects.

Testing milk and cream for butterfat together with the administration of Kentucky's Creamery License Law. Lexington, Ky., University of Kentucky, 1957. 40 p. (Kentucky. Agricultural Experiment Station. Regulatory bulletin, 9 rev.) Apply.

Textbook of meat inspection; including the inspection of rabbits and poultry; 3d ed. Horace Thornton. London, Baillière, 1957. 602 p. 60 s. A new edition which includes information from India, Ceylon, Burma and Iran. The chapters on fish inspection are now omitted.

Food Technology

Bacterial fermentations. H. A. Barker. New York, John Wiley, 1957. 102 p. (CBIA lectures on microbial biochemistry.) Three lectures, each on a different type of fermentation, delivered at Rutgers University.

Future of food preservation. S. C. Lechtman and O. Fanning, eds. Kansas City, Mo., Midwest Research Institute, 1957. 192 p. Proceedings of a Symposium held at the Institute in April 1957.

"Nitrite burn" in cured meat products —particularly in fermented sausages. Robert H. Deibel and James B. Evans. Chicago, American Meat Institute Foundation, 1957. 13 p. (Bulletin No. 32.)

Processing lobster and lobster meat for freezing and storage. J. S. Getschell and M. E. Highlands. Orono, Me., University of Maine, 1957. 15 p. (Maine. Agricultural Experiment Station. Bulletin 558.)

Status report to management on radiation preservation of food. Colonel W. D. Jackson. Washington, Quartermaster General of the Army, 1957. 14 p. processed. On sale by Office of Technical Services, U. S. Department of Commerce. Paper $0.50. (PB-121550)

Studies in food spoilage; heating in feed ingredients and mixtures containing molasses and added fat. J. V. Halick and L. R. Richardson. College Station, Texas, 1957. 7 p. (Texas. Agricultural Experiment Station. Bulletin 860.)

A textbook of dairy chemistry; 3d rev. ed. Edgar R. Ling. New York, Philosophical Library, 1957. 2 v. $12.00. v. 1. Theoretical. v. 2., Practical. All sections completely revised.

Vacuum. A review of developments in vacuu. research. Vol. IV, No. 4, published in June 1957. Edwards High Vacuum Ltd., Crawley, Sussex, England. $2.10.

[1] Material for the list should be sent to Dr. James G. Hodgson, Chief, Library Branch, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

Social, Legal and Economics

Domestic food consumption and expenditure, 1955. Annual report of the National Food Survey Committee, Ministry of Agriculture, Fisheries and Food. London, H. M. Sta. Off., 1957. 152 p. paper. 6s 6d.

Wholesale food market facilities; types of ownership and methods of financing. Harry G. Clowes and others. Washington, U. S. Govt. Print. Off., 1957. 100 p. (U. S. Department of Agriculture. Marketing research report no. 160.) pap. $0.50.

Biological Sciences

Calcium metabolism. James Tutin Irving. New York, John Wiley, 1957. 188 p. (Methuen's Monographs on biochemical subjects.) $2.75. Advanced lectures on calcium metabolism. Author is Professor of Physiology at the University of Cape Town.

Calorie requirements, report of the second committee on calorie requirements. New York, Columbia University Press, 1957. 75 p. (U.N.-F.A.O. nutritional studies, no. 15.) pap. $0.75.

Dairy bacteriology; ed. 4. B. W. Hammer and F. J. Babel. New York, New York, John Wiley, 1957. 614 p. $9.00. A new chapter on the bacteriology of milk production and on the freezing of milk and cream. An expanded chapter on milk enzymes.

Essentials of nutrition; ed. 4. Henry C. Sherman and C. S. Langford. New York, Macmillan, 1957. 505 p. A new revision of a standard work.

Methods in enzymology, v. 4, Special techniques. Sidney P. Colowich and Nathan O. Kaplan, eds. New York, Academic Press, 1957. 991 p. $24.00.

The nutritive value of rice and its by-products. Fayetteville, Ark., 1957. 24 p. (Arkansas. Agricultural Experiment Station. Bulletin, 589.)

Chemical and Physical Sciences

Chimica analitica degli alimenti, v. II. Gli alimenti composti del regno vegetale ed animale. La Legislazione alimentare. La dottzrina della acqua minerali nelle acquisizione odierne. Milano, Ed. Ceschina, 1956. 499 p. L 4500.

Chemistry of plants. Erston V. Miller. Reinhold, 1957. 174 p. Latest developments in plant chemistry. Includes current information on the chemistry of photosynthesis.

Introduction to protein chemistry. Sidney W. Fox and Joseph F. Foster, New York, John Wiley, 1957. 567 p. $9.50. Introductory text covering amino acids, peptides and proteins.

Methods of biochemical analysis. v. 5. David Glick, ed. New York, Interscience, 1957. 514 p. $9.50.

Food Acceptance

Acceptance of an improved frozen sweetpotato puree. Auburn, Ala., Alabama Polytechnic Institute, 1957. 14 p. (Alabama. Agricultural Experiment Station. Circular 121.)

Restaurant acceptance of dehydrofrozen peas; a product test in 100 Milwaukee restaurants. Washington, U.S. Govt. Print. Off., 1957. 27 p. U. S. Department of Agriculture. Marketing research report no. 198.)

ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

Gas chromatography.

RAY, N. H. (Research Dept. Alkali Div., Imperial Chem. Inds. Ltd.). *Nature* 180, 403-5 (1957).

A useful summary of gas chromatography with sections on partition columns and detectors. Applications to physical chemical research are cited.

Separation and identification of four antioxidants, butytlated hydroxyanisole, butylated hydroxytoluene, *n*-propyl gallate, and nordihydroguaiaretic acid, by paper chromatography.

MITCHELL, L. C. (Div. of Food, Food and Drug Admin., Dept. of Health, Education and Welfare, Washington 25, D.C.). *J. Assoc. Offic. Agr. Chemists 40*, 909-15 (1957).

Four antioxidants, BHA, BHT, NDGA, and PG used as additives in food, are separated by application of two dimensional paper chromatography in which refined soybean oil is the immobile phase, and aq. MeOH and H_2O are the mobile phases. The chromatogram is developed with phosphomolybdic acid and ammonia fumes.

Ion exchange micromethods for separation of fermentation acids. Determination of the fumaric acid in fermentation broth.

VAN ETTEN, C. H. AND MCGREW, C. E. (U.S.D.A., Peoria, Ill.). *Anal. Chem. 29*, 1506-9 (1957).

Ion exchange resins offer a simple method for sepn. of fermentation acids prior to detn. by titration. Fumaric acid in fermentation broths is detd. rapidly using a micro ion exchange column. Method also gives information concerning total acidity and nature of other acids present.

The determination of grade strength of pectins by the Teepol-gel procedure.

OLLIVER, M., WADE, P., AND DENT, K. P. (Chivers & Sons Ltd., Histon, Cambridge, Engl.). *Analyst 82*, 127-8 (1957); *Anal. Abstr. 4*, No. 2796 (1957).

A provision standard method for the detn. of grade strength of pectins described by a Sub-Committee of the British Food Manufacturing Inds. Research Assoc. has been critically examd. and inconsistencies have been found that can be overcome by suitable modification. In this modified procedure the pectin soln. is mixed with a determined amt. of Teepol (or other suitable surface-active agent) before being boiled with sugar and acid to produce a gel of sol. solids content of 70.5 ± 0.5% (by refractometer) and pH value of 3.10±0.05. The gel strength is then measured by the Ridgelimeter.

Determination of theophylline and aminophylline by nonaqueous titration.

MCENIRY, M. A. (Food and Drug Admin., Dept of Health, Education, and Welfare, St. Louis, Mo.). *J. Assoc. Offic. Agr. Chemists 40*, 926-9 (1957).

Non-aq. titrations of theophylline and aminophylline in dimethyl formamide with sodium methoxide as titrant and thymol blue as indicator are described. According to the author, this method gives greater accuracy and speed than does the U. S. P. XV procedure for these compds.

Quantitative determination of lactose and monoses in lactose hydrolyzates. Rapid horizontal paper chromatographic method.

ROBERTS, H. R. (Natl. Dairy Products Corps., Oakdale, L. I., N. Y.). *Anal. Chem. 29*, 1443-7 (1957).

A rapid horizontal paper chromatographic technique has been developed for anlaysis of lactose hydrolyzates. By chromatographing at 60° C. with butanol-pyridine-water (9 to 5 to 8) using two 60-min. solvent developments, galactose and glucose are sepd. from lactose. Four solvent developments separate lactose from galactosyl oligosaccharides.

BIOLOGICAL SCIENCES

Biochemistry

The molecular weight of β-lactoglobulin.

TOWNEND, R. AND TIMASHEFF, S. N. (Eastern Utilization Research Branch, Agricultural Research Service, U.S.D.A., Phila., Pa.). *J. Am. Chem. Soc. 79*, 3613-14 (1957).

In a detailed study of the association properties of β-lactoglobulin as a function of pH, it has been found that the wt. of its disperse units is strongly dependent on pH. Ultracentrifuge studies under conditions which favor dissociation confirm the early work of Bull (surface pressure measurements) and recent carboxyl and amino end-group detns. in establishing that the mol. of

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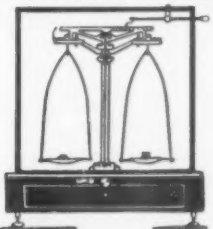

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β-lactoglobulin consists of a single polypeptide chain with a mol. wt. of about 17,500. The generally accepted mol. wt. of 35,000, then, is that of the β-lactoglobulin dimer.

Chemical composition of lemon oil. I. Isolation of a series of substituted coumarins.

STANLEY, W. L. AND VANNIER, S. H. (Fruit and Vegetable Chem. Lab., Western Utilization Research Branch, Agricultural Research Service, U. S. D. A.). *J. Am. Chem. Soc. 79*, 3488-91 (1957).

Seven substituted coumarin compds. have been isolated from domestic cold-pressed lemon oil by chromatographic sepn. on a column of powdered silicic acid. The identity of four of the compds. has been established, viz., 5-geranoxypsoralen, 5, 7-dimethoxycoumarin, 5-geranoxy-7-methoxycoumarin and byakangelicin. A fifth compd. has been tentatively identified as 8-geranoxypsoralen, the geranyl group still being in doubt. The remaining two compds. were recovered in too small a quantity for analysis. However, they appear, from comparison of u.v. spectra, to be related to 5-geranoxypsoralen and 5-geranoxy-7-methoxycoumarin.

Enzymatic decarboxylation of oxalic acid.

SHIMAZONO, H. AND HAYAISHI, O. (Natl. Inst. of Arthritis and Metabolic Diseases, Natl. Insts. of Health, Bethesda, Md.). *J. Biol. Chem. 227*, 151-9 (1957).

Oxalic decarboxylase from *Collybia velutipes* was purified about 400-fold with an over-all yield of about 35%. The enzyme is most active at pH 3.0 and most stable at pH 4.5. It acts specifically on oxalic acid and produces stoichiometric quantities of CO_2 and formic acid. This enzyme does not show any requirement for adenosine triphosphate, coenzyme A, cocarboxylase, acetate, or Mg ion. It is active only in the presence of small amounts of oxygen, although the over-all reaction does not involve net oxidation.

On the acetylation of aliphatic amines by kidney preparations.

PHILLIPS, M. B. AND ANKER, H. S. (Dept of Biochem., Univ. of Chicago, Ill.). *J. Biol. Chem. 227*, 465-71 (1957).

Rat liver slices acetylate both cyclohexyl-L-alanine and *p*-amino-benzoic acid, whereas rat kidney slices acetylate cyclohexyl-L-alanine only. A sol. enzyme obtained from rat or calf kidney catalyzes the formation of acetylcyclohexyl-L-alanine from acetate. This reaction appears to be a reversal of hydrolysis, and the enzyme seems identical with acylase. The implications of this finding are discussed.

Inactivation of lipoprotein lipase by heparinase.

KORN, E. D. (Lab. of Cellular Physiol. and Metabolism, Natl. Heart Inst., Natl. Insts. of Health, Bethesda, Md.). *J. Biol. Chem. 226*, 827-32 (1957).

Incubation of lipoprotein lipase with bacterial heparinase under rather specific conditions results in the inactivation of the lipase. All those conditions which inactivate (or activate) the heparinase have the identical effect on the ability of the prepn. to inactivate lipoprotein lipase. This was interpreted as evidence for the presence of a heparin-like mucopolysaccharide as an integral part of the enzyme, lipoprotein lipase.

Convenient method of obtaining clear filtrates from opalescent protein solutions.

LINDQUIST, B. *Sci. Tools 3*, 17-19 (1956); *J. Sci. Food Agr. 8*, i-257 (1957).

An opalescent protein soln. (e.g., of milk or cheese proteins) is dialyzed through a membrane-filter and quite clear solns., suitable for electrophoretic examn., are obtained.

NUTRITION

The growth effect of D-valine.

WOMACK, M., SNYDER, B. B., AND ROSE, W. C. (Div. of Biochem., Noyes Lab. of Chem., Univ. of Illinois, Urbana). *J. Biol. Chem. 224*, 793-802 (1957).

Diets containing 1% of D-valine are incapable of supporting the growth of weanling rats despite the fact that this intake level of L-valine provides more than enough of the amino acid to permit optimal gains in wt. When the D-valine content of the food is raised to 2%, slow growth occurs. However, even at the higher level, the gains are extremely poor as contrasted with those induced by half as much of the L-isomer.

Effect of varying levels of DL-tryptophan in diet on dental caries in rats.

BUTTNER, W. AND MUHLER, J. C. (Indiana Univ., Dept. of Chem. and School of Dentistry, Bloomington). *Proc. Soc. Exptl. Biol. Med. 95*, 309-11 (1957).

Dental caries experience in rats was studied following feeding of varying levels of DL-tryptophan as a constituent of a cariogenic diet. When either 0.6 or 1.8 g/kilo tryptophan was added to the diet there was an increase in dental caries, although the differences were not significant. When the diet contained 5.4 g/kilo tryptophan there was a significant increase in incidence of dental caries. Concomitant with the increased dietary tryptophan level, there was an increased salivary tryptophan concn.

Effect of dietary gluten on the fecal fat in the rat.

RIBEIRO, E., SOBRINHO-SIMOES, M. AND MESQUITA, A. (Depts. of Internal Med. and Biol. Chem., Univ. of Porto, Faculty of Med., Portugal). *Metabolism Clin. and Exptl. 6*, 378-80 (1957).

In normal rats the addn. of small quantities of wheat gluten to the diet significantly increases fecal fatty material. The significance of this finding with respect to the effect of alimentary gluten in some clinical conditions with steatorrhea is discussed.

Absorption of monoglycerides.

TIDWELL, H. C. (Dept. of Biochem., The Univ. of Texas, Dallas). *Am. J. Physiol. 189*, 537-40 (1957).

The rate of absorption of glyceryl monooleate, when fed alone, appeared to be much slower than that of other glycerides. In contrast, the chylomicronemia was markedly greater after feeding olive oil, Tween 80, or 1:1 mixtures of the glyceryl monooleate and olive oil or the fatty acids prepared from it. The slower absorption of the monoglyceride was not assocd. with a decreased lipid retention over a longer period, because eventually all of the lipid became available for absorption. Observation showed that the retention in these attempts could not be attributed solely to gel formation, but more likely to a decreased gastric motility.

Some biokinetic aspects of calcium metabolism in dairy cows.

LUICK, J. R., BODA, J. M. AND KLEIBER, M. (Dept. of Animal Husbandry, Univ. of California, Davis). *Am. J. Physiol. 189*, 483-8 (1957).

A procedure is presented by which the reservoirs of mobilizable skeletal Ca may be estimated. It appears that these reservoirs of skeletal Ca are larger and are turning over more slowly in cows which were prefed low Ca: high P diets. A comparison of bone Ca specific activity to serum Ca specific activity indicates that nearly all the trabecular bone Ca and from 7 to 17% of the cortical bone Ca (depending upon dietary Ca/P) may be included in the "mobilizable Ca pool."

CO_2 output and energy balance of hereditary obese mice.

MCCLINTOCK, R. AND LIPSON, N. (Dept. of Physiol., Univ. of Minn., Med. School, Minneapolis). *Am. J. Physiol. 189*, 463-9 (1957).

The total CO_2 outputs of young adult hereditary obese-hyperglycemic mice were measured over 2-day periods by means of the D_2O^{18} method. The CO_2 outputs, which reflect the energy outputs, were of approx. the same magnitude for the two groups at 6 and 9 weeks

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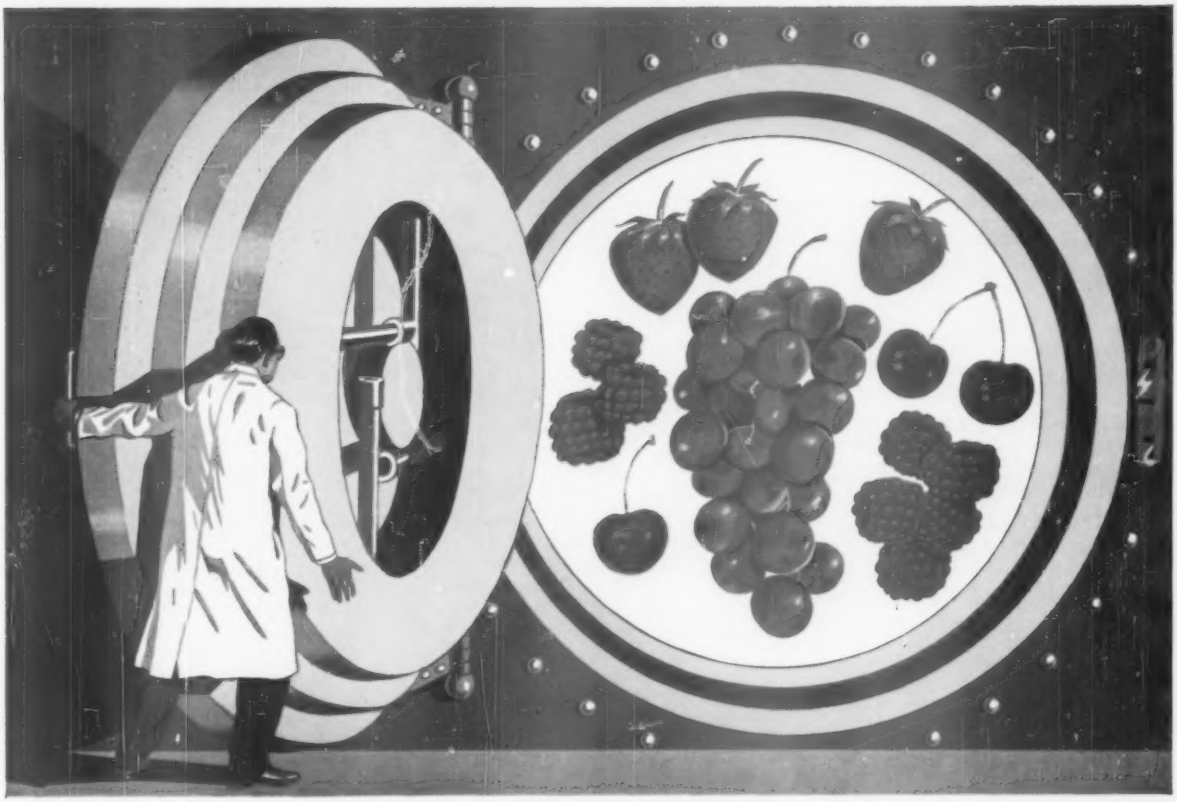

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of age, but were greater for the obese at 12 weeks. Food consumption remained nearly constant for both groups.

Effect of fructose feeding on glucose tolerance in man.

VAN ITALLIE, T. B. AND SHULL, K. H. (Dept. of Nutrition, Harvard Sch. of Public Health, Boston). *J. Lab. Clin. Med. 50*, 391-9 (1957).

The effect on glucose tolerance of an adequate diet contg. fructose as the sole carbohydrate was detd. in a series of normal subjects. It was concluded that the impaired glucose tolerance assocd. with carbohydrate deprivation is due principally to a decreased uptake of glucose in the extrahepatic tissues, and that the effect of fructose feeding on glucose tolerance is entirely different from that of carbohydrate restriction.

Abnormally high pyridoxine requirement. Summary of evidence suggesting relation between this finding and clinical pyridoxine "deficiency".

HUNT, A. D. (Hunterdone Medical Center, Flemington, N. J.). *Am. J. Clin. Nutrition 5*, 561-5 (1957).

The need for an unusually high intake of vitamin B_6 is a rare but apparently well-documented phenomenon. Thus far the symptoms of the condition have been either convulsions or anemia, with or without biochemical evidence of pyridoxine deficiency. In general, there appears to be a strong tendency for a deficiency of this vitamin to reveal itself by the production of convulsions in young infants, while adults show other manifestations. Present knowledge permits little more than a descriptive discussion of these metabolic lesions, the more exact definition of which must await extensive clinical and biochemical investigation.

Clinical and biochemical observations in galactosemia.

ISSELBACHER, K. J. (Harvard Med. School, Mass. General Hospital, Boston). *Am. J. Clin. Nutrition 5*, 527-32 (1957).

Galactosemia constitutes a hereditary disease in which galactose cannot be metabolized normally. The outstanding features are nutritional failure, hepatosplenomegaly with cirrhosis, metal retardation and cataract formation. The disease results from the congenital deficiency of a specific enzyme, P-Gal transferase (phospho-galactose uridyl transferase). As a consequence, galactose cannot be properly utilized and galactose-1-phosphate accumulates in the tissues. Effective treatment is possible by the institution of a galactose-free diet. Complete disappearance of symptoms may occur if the diagnosis is made early and the dietary regimen is promptly instituted.

Functions of water in the body.

ROBINSON, J. R. (Med. Research Council Dept. of Exptl. Med., Univ. of Cambridge, Engl.). *Proc. Nutrition Soc. (Engl. and Scotland) 16*, 108-12 (1957).

Water as a suitable milieu in which the metabolic processes of living cells can take place, its dependence on various osmotic forces, in respect to its internal movements, and the fine adjustment of its exchanges with the external environment through the mechanisms of thirst and, secretion of antidiuretic hormone, was discussed.

The relationship of water and salt.

ELKINTON, J. R. (Chem. Section of the Dept. of Med., Univ. of Pennsylvania Sch. of Med., Phila.). *Proc. Nutrition Soc. (Engl. and Scotland) 16*, 113-18 (1957).

The total vol. of H_2O in the body depends on the total amt. of the principal ionic solute Na. The relationship of H_2O, salt and the body is discussed.

Nutritive value of quinua proteins.

QUIROS-PEREZ, F. AND ELVEHJEM, C. A. (Biochem. Dept., Univ. of Wisconsin, Madison). *J. Agr. Food Chem. 5*, 538-41 (1957).

Quinua (*Chenopodium quinoa*, Willd), an Incan seed, used in human nutrition, supplies protein of high quality as judged by growth and lipotropic responses, in white weanling rats. Combinations of quinua and casein, giving the same total dietary protein as that supplied by quinua alone did not support better growth than quinua, confirming the findings of other workers. However, the addn. of 3% casein to quinua, giving a total dietary protein 12.42%, produced an excellent growth of 36.7 g. per rat per wk. and a normal liver fat.

Toxic protein from trichlorethylene-extracted soybean oil meal.

MCKINNEY, L. L., WEAKLEY, F. B., CAMPBELL, R. E., ELDRIDGE, A. C. AND COWAN, J. C. (Northern Utilization Research and Development Div., Agr. Research Service, U.S.D.A., Peoria, Illinois). *J. Am. Oil Chemists' Soc. 34*, 461-6 (1957).

Fractionation studies have been carried out on a specially prepared undenatured toxic trichloroethylene-extracted soybean oil meal to det. which component of the meal is assocd. with the toxicity. Calf-assay of the samples indicated that the toxic factor is associated with the protein. Analyses of the toxic protein failed to indicate the nature of the reaction of trichloroethylene with the protein to produce the toxicity.

Physiology and Medicine

Comparative in vivo methods for evaluating antacids in humans.

HARRISSON, J. W. E., ABBOTT, D. D., FEINMAN, J. I. AND PACKMAN, E. W. (LaWall and Harrisson Research Labs., 1921 Walnut Street, Phila., Pa.). *J. Am. Pharm. Assoc., Sci. Ed. 46*, 549-52 (1957).

A continuous pH recording device is described whereby gastric acidity may be detd. accurately without removal of gastric juice from the stomach. The instrument can be assembled from equipment readily available commercially. By use of the instrument described, four compds. have been tested for their efficiency as antacids. The antacids, listed in decreasing order of effectiveness, are dihydroxy aluminum sodium carbonate, $Al(OH)_3$, $CaCO_3$ and $NAHCO_3$.

Reduction in elevated blood cholesterol levels by large doses of nicotinic acid.

PARSONS, W. B. AND FLINN, J. H. (Dept. Internal Med., Jackson Clinic, Madison, Wis.). *J. Am. Med. Assoc. 165*, 234-8 (1957).

Administration of nicotinic acid (niacin) orally in large doses (3 to 6 gm. daily) to 24 patients with hypercholesteremia resulted in significant reduction in blood cholesterol levels in 16 (66.7%). Normal levels were attained in 6 of 8 patients followed for 30 weeks or longer and in 7 of 16 additional patients followed for at least 12 weeks. No serious side-reactions or toxic effects have been observed which can be attributed to nicotinic acid. Nicotinic acid proved to be effective in lowering cholesterol levels despite continuation of the patients' customary diets.

Food and Food Technology

Cocoa and Cocoa Products

Rheological properties of dark chocolate masses.

HEISS, R. AND BARTUSCH, W. *Fette, Seifen, Anstrichmittel 58*, 868-75 (1956); *Food Sci. Abstr. 29*, No. 1134 (1957).

Technological factors which influence the flow properties of chocolate mass are distribution of particle size, H_2O content, duration and type of conching procedure, fat content, addn. of lecithin, aging of the mass, and temp. and degree of seeding. Recent exptl. work illustrating the effect of these factors on viscosity measurements in chocolate mass are reported.

Coffee and Tea

The soluble mannan of roasted coffee.

THALER, H. (Deutsch. Forschungsanstalt fur Lebensmittelchemie, Munchen, Ger.). *Z. Lebensm. Untersuch. u. Forsch. 106*, 128-32 (1957).

Roasted coffee contains galectomannan which is not present in green coffee. Presumably it is formed from the carbohydrates of the green bean cell wall at roasting temperatures by processes that are reminiscent of the dextrinization of starch. Apparently, there are varietal

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differences, as 1.8% was found in Robusta and 2.3 to 3.2% in Santos and Columbia coffees.

Fruits and Vegetables

Chemistry and technology of citrus, citrus products, and by-products.

U. S. D. A. AGRICULTURAL RESEARCH SERVICE. *U.S.D.A. Handbook No. 98*, 1956, 99 pp.

More attention is constantly being given to processing and utilization of citrus for purposes other than the fresh-fruit market to more effectively market the ever-expanding citrus production of U. S. This handbook deals with the chemistry of citrus fruits; processing of juice by canning, concn., freezing, drying, and sulfuring; canning of mandarin and grapefruit sections; prepn. of orange vinegar, brined and candied fruit and peel; waste disposal; and prepn. of such citrus by-products as citric and lactic acids, industrial alc., pectins, feed yeast, seed oils, essential oils, and citrus feed and molasses.

Preparation of a fruit beverage from German fruit.

KOCH, J. *Fruchtsaft-Ind. 1*, 253-9 (1956); *Food Sci. Abstr. 29*, No. 979 (1957).

Directions are given for the com. prepn. of a fruit beverage from rather poor quality apples; the raw juice is concd. and H_2O and a natural essence are added, and the juice is then carbonated with rather more CO_2 than is generally used in the prepn. of similar beverages.

Meat and Meat Products

Production of carbonyl compounds during irradiation of meat and meat fats.

BATZER, O. F., SRIBNEY, M., DOTY, D. M. AND SCHWEIGERT, B. S. (American Meat Inst. Foundation and Dept. of Biochem., Univ. of Chicago, Ill.). *J. Agr. Food Chem. 5*, 700-3 (1957).

Investigation of chem. changes that occur when meat and meat products are subjected to γ-radiation for sterilization indicated the formation of carbonyl compds. Extraction procedures and the behavior of the compd. with various chromatographic solvent systems suggested that those obtained from irradiated meat differ from those obtained from irradiated fat. Carbonyl compds. increase in both meat and fat with increasing irradiation dosages.

Milk and Milk Products

A volumetric method for estimating the undenatured serum proteins in nonfat dry milk.

ANDERSON, H. A. (Eastern Utilization Research and Development Div., Agricultural Research Service, USDA, Washington, D.C.). *Abstr. A.D.S.A. Meeting, June 1957.*

A rapid and simple method for detg. the suitability of nonfat dry milk for breadmaking or for other specific uses was developed. Diluted AcOH was added to reconstituted nonfat dry milk and the ppt. of casein and denatured serum proteins was removed by filtration. Phosphotungstic acid was added to the filtrate in a suitable centrifuge tube and the vol. of the ppt. was noted after centrifuging under controlled conditions. The vol. of the ppt. can be correlated with the mg. of soluble whey protein nitrogen per gm. of nonfat dry milk.

Starches and Syrups

A new specialty corn syrup.

CLAY, C. (Wynnewood, Pa.). *Manufg. Confectioner 37*, 213 (1957).

A unique modified corn syrup, first reported in Germany, shows great promise in hard candy manufg. The syrup contains dextrose and maltose with the regular 42DE and 80% solids. The high viscosity of the syrup makes it difficult to handle, but it can be worked. As a coating for pulled peppermints the low hygroscopicity of the syrup allows the candies to be loose packed for extended time periods without sticking.

Miscellaneous Information

Viscosity changes of sodium alginate solutions after freezing and thawing.

SCHWARZ, T. W. AND LEVY, G. (Univ. of California Sch. of Pharmacy, San Francisco). *J. Am. Pharm. Assoc., Sci. Ed. 46*, 562-3 (1957).

The viscosity of solns. of sodium alginate used in this investigation is increased after freezing and thawing. The relative increase of viscosity depends upon the concn. of sodium alginate and the method used for the prepn. of the soln. The effects of glycerin, propylene glycol, and Ca lactate on the viscosity of solns. of sodium alginate before and after freezing are shown.

INDUSTRY PUBLICATIONS

"Corn Oil" is a new 20-page illustrated booklet describing the manufacture and uses of corn oil and methods of packaging, storing and handling the product. The booklet has been published by the Corn Industries Research Foundation, Inc. as the third in a series which includes "Corn Starch" and "Corn Syrups and Sugars." The booklet also has an appendix containing analytical data on physical and chemical properties. Copies are free upon request to the foundation at 3 E. 45th St., New York, N. Y., or 1001 Connecticut Ave., N. W., Washington, D. C.

The latest Dodge & Olcott, Inc. **price list of essential oils, aromatic chemicals and certified colors** is now off the press and ready for general distribution. More than 1,500 items are listed including essential oils, balsams and gums, resinexes, aromatic chemicals, oleoresins, tinctures, vanilla concentrates and certified pure food and cosmetic colors. Copies upon request to Dodge and Olcott, Inc., 180 Variek St., New York 14, N.Y.

The new 1958 "Physical Properties" booklet by Union Carbide Chemicals Corp. is now available on request from the company by writing to 30 E. 42nd St., New York 17, N. Y. The 28-page booklet is a guide to Carbide's products and services, presenting the latest physical property data on more than 350 organic chemicals. Fifty new chemicals, introduced by the company since the previous edition, are featured in the new booklet.

A catalog describing the new 30-inch vibrating screen separators has recently been issued by the manufacturer, Southwestern Engineering Co. The new equipment rounds out the SWECO separator line. The two-color brochure presents operating application and specification data. It can be had by writing the firm's Separator division, 4800 Santa Fe Ave., Los Angeles 58, Calif. and asking for bulletin S 574-1.

Latest data on standards and optional designs of Impervite brand impervious graphite tube and shell heat exchangers are covered in a new technical bulletin No. 448. Subjects covered include effective transfer surfaces, characteristics of Impervite, a tabula-

tion of dimensions of the standard exchangers up to 16-foot lengths and 38-inch shell diameters, and a semi-detailed discussion of the standard but optional designs available. Copies are available upon request to John Reys, chief engineer, Falls Industries, Inc., Aurora Road, Solon, Ohio.

A book describing **silent chain drives** is now available from Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill. The 88-page book No. 2425 covers tiny fractional horsepower drives used in small power tools to huge drives transmitting thousands of horsepower. It contains tables of service factors, ratings, chain length and center distance computations. A 22-page section outlines the procedure for selection of engineered drives.

A new technical service bulletin describing **Zeolex as an anti-caking agent** for conditioning sugar has been published by J. M. Huber Corp., 100 Park Ave., New York 17, N. Y. The bulletin describes pressure caking and 90% relative humidity caking tests with sugar. Copies are available upon request.

Two **wall charts** containing suggestions on "How to Handle Becco Hydrogen Peroxide Safely" and "How to Test Becco Hydrogen Peroxide Bleaching Solutions" are offered by Becco Chemical division, Food Machinery and Chemical Corp., Buffalo 7, N. Y.

Each chart is 16 by 22 inches in size and printed in large type for reading at a distance. The safety chart lists handling precautions and recommends action in case of contact. The testing chart covers peroxide concentrations and alkali concentrations.

(Continued on 56)

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IN MEMORIAM

Robert J. Remaley

The sad news of the death of Robert J. Remaley of coronary thrombosis on Friday, November 15, 1957, came as a severe shock to his host of friends and fellow scientists in the food industry and in food research and development organizations across the nation.

"Bob" was an outstanding and widely known figure in the dairy field and since 1951 had been on the American Dry Milk Institute staff (Chicago) where he was in charge of scientific development and the laboratory department. During World War II he was head of the Dairy Branch of the QmC Subsistence Research and Development Laboratory, commanded by Colonel Rohland A. Isker. Bob Remaley's understanding of the problems and excellent cooperation assisted the industry in its contributions to the war effort. Prior to his service with the QmC and the ADMI, he was with Kraft Foods Company in Chicago for 17 years.

Bob's many friends and close associates throughout the industry knew him as a conscientious and thorough worker, outstanding for his friendliness and his sense of ease in the midst of complicated and detailed work.

He is survived by his widow Gail and a daughter Harriet, his mother, Mrs. Eleanor Ramaley, a brother, J. W. C. Remaley, and his father- and mother-in-law, Mr. and Mrs. L. K. Riggs.

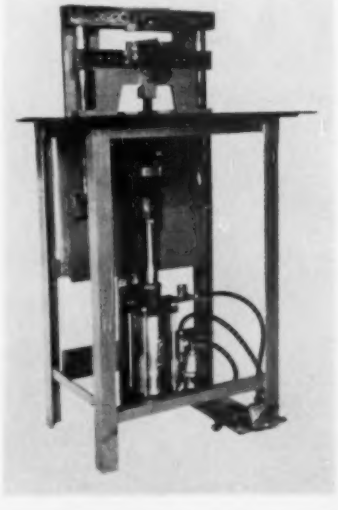
Herbert E. Otting

It is with much sorrow that we announce the death of our associate and colleague, Mr. Herbert E. Otting. Mr. Otting passed away on Sunday morning, November 17th, at his home in Minerva Park, Ohio. Mr. Otting was born at Warren, Ohio on July 28, 1889. After graduation from high school he attended the Ohio State University where in 1913 he received the B.S. degree in Agriculture. Immediately after graduation he became a chemist with the John Wilde Evaporated Milk Co. at Columbus, Ohio. Subsequently, he served in a similar capacity with the Nestle's Food Co. at New York City, the Carnation Co. at Corry, Pa., and the Moores and Ross Milk Co. of Columbus, Ohio. In 1929 he became chief chemist of the newly organized M & R Dietetic Labs., Inc. and held this position as Director of Quality Control until his retirement at the end of 1954. He was a member of the Board of Directors of the M & R Dietetic Labs., Inc. and was active in an advisory capacity to the Company at the time of his death. He was the author of a number of technical articles in his chosen field of work and was granted 14 U. S. patents in the field of milk and food processing during the years he was associated with the M & R Dietetic Labs., Inc. Mr. Otting was a charter member of the Institute of Food Technologists. He was also a member of the American Dairy Science Association, the American Chemical Society, and the American Oil Chemists Society.

Contributed by O. F. Garrett

EQUIPMENT

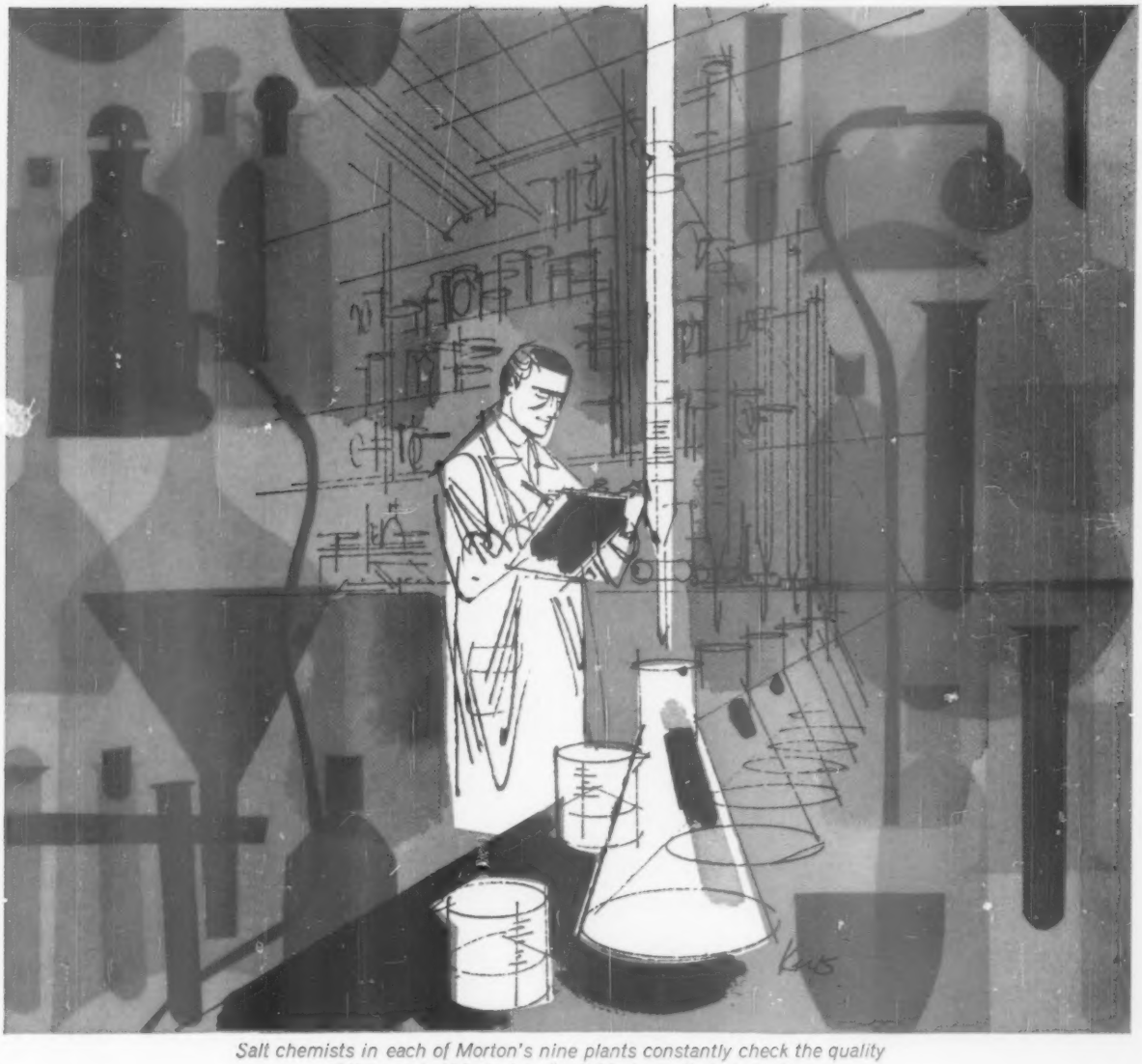
This multi-unit packaging machine has been developed by Tee-Pak, Inc., 3520 S. Morgan, Chicago, Ill., to use cellulose bands. It fits the seamless band over the products combining them into a secure single package. Production rate is 20 units a minute for most applications. Tension of the band can be controlled to permit the banding of heavy products, where strength is required, as well as fragile items.



The new "Spineraft" **automatic speedfilter** is said to cut filtration time for light or heavy precipitates. Unit consists of two 3.5 liter tanks, used independently or together, with pressure obtained from gas or a compressor. Unit has a rang of 0 to 125 p.s.i. and completes the filtration process automatically. Can be converted to a large-capacity ultra filter by adding a cellophane filter. Distributed by Scientific Products, division of American Hospital Supply Corp., 1210 Leon Place, Evanston, Ill.

Gas sterilizing equipment, known as "Sterox-O-Matic" system, is available for industrial use from the Wilmot Castle Co., 1906 E. Henrietta Rd., Rochester, N.Y. There are several models which are designed to sterilize contents of pre-sealed plastic, paper, or cardboard containers, "Steroxcide 20", a combination of ethylene oxide and carbon dioxide, has been selected as the sterilizing medium in the new unit.

A new **one-pan analytical balance** for weighings from 0.1 milligram to 200 grams has been announced by the Christian Becker division of the Torsion Balance



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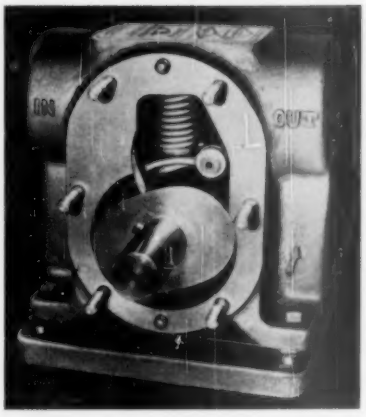
Co., Clifton, N. J. Among the design features of this model NA-1 is the two-beam construction. All weighings, from 1 to 200 grams, are made to within 1 gram on a "rough weighing" beam.

Two amber lights indicate which way the weight control knob should be turned to adjust the balance to within one gram. A larger image is projected by the new optical system which produces an image of 10,000 parts, each part being 0.1 mg.

A new **hinged-door type sterilizer** with an opening designed to accommodate large trays and other large items has been developed by the Barnstead Still & Sterilizer Co., 341 Lanesville Terrace, Boston 31, Mass. Units are available in single or double-wall construction. As an additional safety feature, the Barnstead "Autoclave" has been built in to lock the door handle so it cannot be rotated while there is pressure in the chamber. All models have automatic pressure controls. Gas, electric and steam-heated models are in the line.

Filtration Fabrics division of Filtration Engineers, 155 Oraton St., Newark, N. J. is now offering custom-tailored filter cloth bags with polyethlene zippers. The zippers are said to be corrosion-resistant and jam-proof. They are sewn to the cloth with a specially-developed stitch that prevents leaking.

A newly designed "Twin-Lobe" rotary positive displacement pump

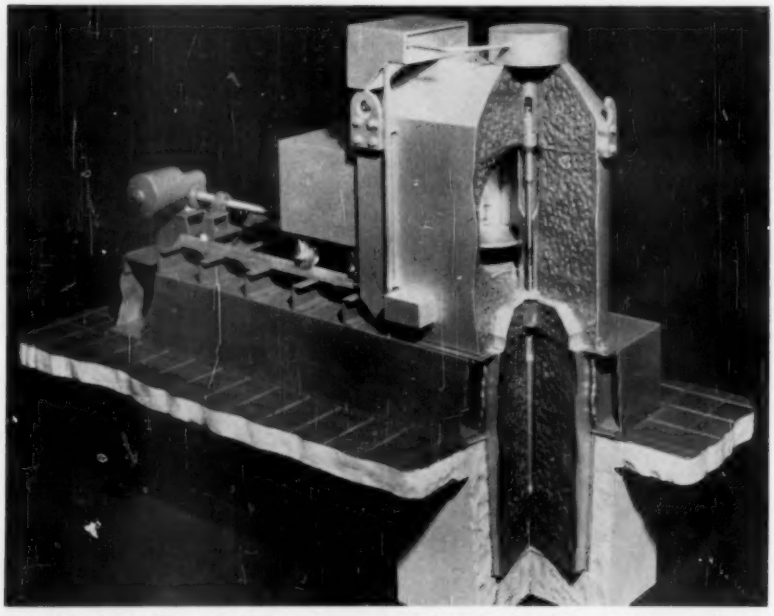


has been developed by Manton-Gaulin Mfg. Co., Everett 49, Mass. It features a "twin-lobe" design of the rotating element which is said by the company to provide a smooth performance. It is designed for moving a wide range of products, from volatile gases to viscous materials like pastes, pie fillings and cherries. Four models are available.

A residual chlorine analyzer (Model 17A1100) that is said to provide continuous automatic measurement of free, combined, or total residual chlorine in water, has been developed by Fischer & Porter, 465 Jacksonville Rd., Hatboro, Pa.

A **"Sanitary Prebreaker"** which provides a method of coarse breaking, crushing or shredding a wide variety of tough and bulky organic and inorganic materials has been developed by the Rietz Mfg. Co., West Chester, Pa. The machine features optional discharge orifice plates which are said to control the maximum size of the end product.

It also has hinged construction that exposes the entire interior of the machine for cleaning. The prebreaker has been designed without sharp knives, which the company states will eliminate the need for resharpening or replacement of these wearing parts. Test data and application information is available.



The "Model A Hotrodder" is a new research tool developed for studying radiation applications in such processes as the pasteurization and sterilization of foodstuffs, the sterilization of pre-packaged pharmaceuticals, the production of plastics and chemicals, and others. Said to require no shielding room, monitoring system or alarm. It utilizes radioactive Cobalt in the irradiation process. Nuclear Systems, a division of the Budd Co., 2450 Huntington Park Ave., Philadelphia 32, Pa., is the manufacturer.

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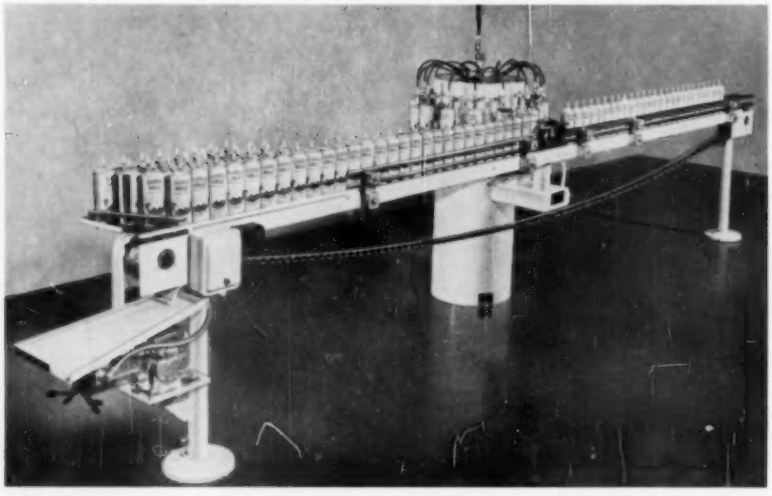
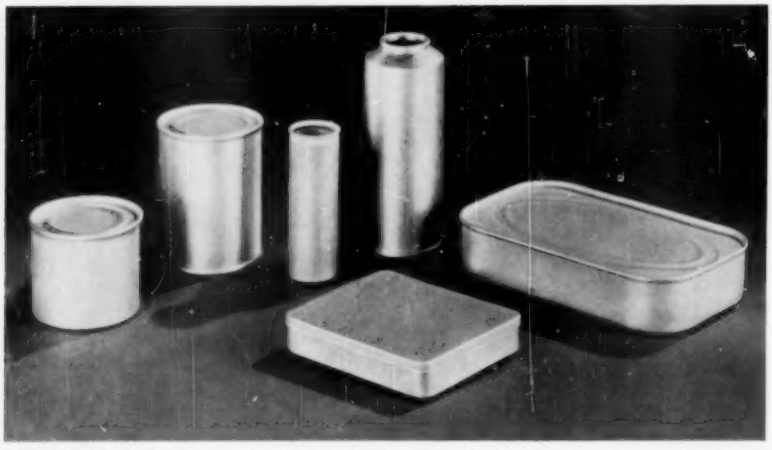


Alpha Engineering and Machine Works, Inc. has introduced a new rotary feed machine that combines Aerosol can gassing and mixing. Named the Alpha A-206 "Roto-Shake," this machine automatically moves cans along a pallet-type conveyor to a central rotary feed head. Here the cans are automatically gassed and shaken as they travel through the feed cycle and then moved again to the conveyor for automatic removal from the machine. The company offers complete information by writing to 838 W. Central Road, Mt. Prospect, Ill.



This is one of the first photographs of the representative aluminum can styles being presented by Continental Can Co. These are general types of containers which can be made available to a variety of packers. From left to right there is a two-piece drawn can, a three-piece open top cemented side seam can, an extruded can which can either take a cup and valve or a slip cover, and a large-size extruded aerosol can. The smaller flat can is a drawn oblong hinge cover box and the larger is a drawn two-piece rectangular can.

EXPANSION NEWS

The Givaudan Corp. and its associate companies, Givaudan-Delawanna, Inc., Givaudan Flavors, Inc., and Sindar Corp., are now preparing new, enlarged executive and sales offices for occupancy next spring. The company has leased the seventh and a portion of the eighth floor of the Warner Brothers Building at 321 W. 44th St., New York 36, N. Y. Larger laboratories and other facilities will be the result of this move.

PRODUCTS

An all-purpose W/O emulsifier, which has wide use in Europe, is now being distributed in the United States by Morningstar, Nicol, Inc. The new product, Emocithin, is destined exclusively for the preparation of W/O emulsions, where aqueous phases are finely dispersed in continuous oil or fat phases of vegetable, animal, or mineral oils. Uses suggested include the improvement of margarine manufacture, the building of anti-staling characteristics into bread and other baked goods, preventing the separation of water from the fat content in pet and dog food, and the treatment of grease to spread further and more uniformly on baking pans or trays.

The chart shows that in contrast to other emulsifiers of the W/O type, such as mono- or diglyceerides of fatty acids, Emocithin produces W/O emulsions which will not separate at temperatures up to 200 degrees F.

MEMORANDA

"The Story of Life in a Large Corporation" is the interesting story of the DuPont Co. as a representative firm in the U. S. In a 32-page illustrated booklet, the company shows that a large corporation today is in fact a cross-section of the public in the United States today.

It graphically points out that "the stereotype of the 'corporate man' is a patently false conception. Corporation people are not types but a cross-section of America." The booklet covers the life of the industrial employee, the white collar worker, the scientist, the management as well as showing the place of the stockholder in corporation life.

Dr. Harold L. Rice, a nutrition expert from the Du Pont Co., told an audience at the recent annual

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Klenzade proudly presents the industry's most distinctive line of sanitation-engineered brushes to further expand Klenzade Sanitation Services. The same progressive techniques that have made Klenzade sanitation chemicals famous throughout the western hemisphere have been applied to the design and construction of these brushes. You may buy Klenzade Brushes with confidence and the knowledge that they are the finest brushes obtainable. Klenzade Brushes will raise sanitation standards in your plant . . . and on the farms of your producers.

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conference of the Maryland, Delaware, and District of Columbia Hospital Associations, that bread supplemented with lysine amino acid is one of the most economical ways of providing hospital patients with the high quality protein diet required for speedy convalescence. He said the bread can be supplemented with this amino acid in the correct proportion to help build its tissue building value by commercial bakers without changing its taste or texture.

"A new era of foods tailored for the nutritional needs of various segments of our population" was the topic discussed by Carl B. Henrichson of the DuPont Co. at the November meeting of the New York section of IFT.

Mr. Henrichson compared the "Tailor-made food era" with the development of "convenience foods" and the elimination of seasonal variations and quality variations in foods available to American tables.

His talk was entitled "The Current Status of Synthetic Sweeteners in Use by the Food and Beverage Industries." He credited food technologists with "the inventiveness and imagination" to accomplish the recent achievements.

"Now," he said, "there is a need for low-calorie foods that will satisfy the appetite of the American consumer who tends toward overweight, and enable him to continue to enjoy eating and yet avoid the health problem that comes from over-consumption of calories."

He challenged the group by stating: "The key to success in the development of low-calorie food products lies not in trying to duplicate normal calorie foods, but in the ability of food technologists to create new, low-calorie food concepts which will satisfy various appetites."

Four large firms, Armour & Co., Continental Can Co., Food Machinery & Chemical Corp., and General Foods Corp., have joined forces with the Army Quartermaster Corps in setting up the world's first food radiation center.

The companies are working with the Army to develop a method for preserving a wide variety of foodstuffs by subjecting them to different types of nuclear emanations. The companies have formed Irradiated Products, Inc., an independent industry group, which will conduct the production planning and operation of a new facility which has been designated as the U. S. Army Ionizing Radiation Center at Sharpe General Depot, Lathrop, Calif.

The center will consist primarily of a food processing plant utilizing an electron accelerator. In operation, the IPI will combine its industrial knowledge with the Army's extensive research program. It was announced that 150 employees will be needed the first year and as high as 250 by the second year.

A short course on food plant sanitation will be held at the University of Illinois, Champaign, Ill., February 3 to 8. The course, according to Professor Richard Marsh, coordinator, will consist of "Down to earth, practical and tailored-to-measure" instruction in basic science, principles and techniques needed in an effective food plant sanitation program.

PERSONNEL

Dr. Ernest Guenther, vice-president and technical director of Fritzsche Brothers, Inc. and a member of IFT, recently returned to New York after a six-month assignment in African territories.

Dr. Guenther, a specialist in the study and elucidation of essential oil production throughout the world, traveled in Kenya Colony, Southern Africa, Madagascar, the Comoros and Reunion Islands. He kept his firm and the industry informed of his investigations by frequent issue of "Guenther Reports" from various places.

In addition to a perceptive study of each area's economic conditions, Dr. Guenther's survey covered the production of oils of geranium, mahwah, lemongrass, vetiver, ylang ylang, eucalyptus, clove, cedar wood, various citrus oils and the cultivation of vanilla beans.

Dr. Norman W. Desrosier, formerly professor of food technology at Purdue University, has accepted the post of Deputy for Radiation Preservation at the Chicago Quartermaster Food and Container Institute for the Armed Forces, U. S. Army Quartermaster Research and Development Command. Dr. Desrosier will direct the radiation preservation project along the lines presently established and, with the assistance of the various research groups now pioneering in this challenging field, will seek to correlate and consolidate the scientific gains now discernible.

Dr. Desrosier

Dr. Lloyd A. Hall, Technical Director, The Griffith Laboratories, Inc., was one of twelve Distinguished Citizens who received an Award of Honor from the Chicago Committee of One Hundred, for outstanding civic work, at a banquet on November 29, 1957. The honorees were selected on the basis of their contributions in the area of human relations and their achievements in advancing the general welfare of the City of Chicago.

Mr. George J. Malecki, a longtime member of IFT has opened a consulting service for the food industry with offices at 519 Surf Street, Chicago 14 (Tel. Wellington 5-0517).

He will specialize in produce development and diversification of production programs.

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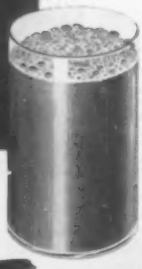

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9 **Long processing times for my canned goods damage texture and flavor, and adversely affect vitamin retention.**
Perhaps thermally processed grains or grits or flours low in thermophilic bacteria will be of value to you.

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It has recently been announced that Dr. Ernst T. Theimer has been appointed Director of Research for van Ameringen-Haebler, Inc. Dr. Theimer has been engaged in various research activities with VAH since 1931. His new responsibilities include direction of research on aromatic products and processes, as well as on new analytical techniques for product quality control.

Dr. E. T. Theimer

He holds two degrees in chemistry from the University of Cincinnati and received his Ph.D. at New York University. He has long been active in the Essential Oil Association, and is charman and founder of its Instrumental Analysis committee. He is also a member of the American Chemical Society and is a national councilor for that organization.

The appointment of K. H. Rowland as vice-president of production of Union Carbide Chemicals Co., division of Union Carbide Corp., was recently announced by E. E. Fogle, division president. Mr. Rowland, who joined the company in 1934, was previously works manager.

N. W. Chmura

J. A. Kaiser

Two scientists, recently employed by the Research Laboratories of Swift & Company, are Norman W. Chmura, Ph.D. (University of Maryland) and John Alfred Kaiser, M.S. (University of Wisconsin). Dr. Chmura will be engaged in a project on the bacteriology of meats and meat processing and Mr. Kaiser on the technology of baby foods development and manufacture, specifically meats.

Paul Murphy, general manager of packaging market sales for Reynolds Metals Co., has been named a vice-president of Reynolds Aluminum Sales Co. He will continue to direct all of the firm's packaging division operations in the new role as vice-president. Mr. Murphy joined the company in 1935 as a mail clerk and from that time has risen through the years to his present position.

Paul Murphy

Quality Bakers of America Cooperative, Inc. has named Kenneth R. Rand as director of engineering. In his new position, Mr. Rand will be closely allied with Dr. R. Oscar Skovholt, a member of IFT, who is director of laboratory, and Herman Hanschka, director of production.

K. R. Rand

Dr. Edward F. Kohman, longtime member and active worker in IFT, was the subject of an article in the July issue of the JOURNAL OF CHEMICAL EDUCATION. A tribute to Dr. Kohman and recognition for his contributions to the canning industry form the substance of this excellent article by E. V. McCollum, Johns Hopkins University, one of a series on the "Spirit of Technological Research." Dr. Kohman has contributed findings to the research on can corrosion, tin-iron relationships, vitamin retention, flavor losses, the methodology of flavor measurement, and the role of enzymology in loss of flavor as well as in the enhancement of flavor.

Henry H. Ottens Mfg. Co., Inc. has opened a branch office at 93 Winsor Ave., Watertown, Mass., a suburb of Boston. This move by the company is to offer additional service to customers in New England. **George C. Robinson, Jr.**, New England manager, will be in charge of the office.

William E. Conway, former superintendent of the Gumming and Sure-Hold divisions of the Nashua Corp., has been named to the post of executive assistant to the manager of manufacturing. At the same time it was announced that J. Robert Merrill, Gumming division engineer, has been promoted to superintendent of the Gumming and Sure-Hold divisions, replacing Mr. Conway.

Dr. Bruce Morgan, recently appointed to a position on the research staff of the Continental Can Company, is now established at that Company's research and development facility at 1350 West 76th Street, Chicago. Dr. Morgan was formerly the director of the radiation preservation of food project sponsored by the quartermaster Corps and led the step-by-step development of a program that has now ramified into a broad attack on the complex chemical, biological, and physical problems involved. At Continental, Dr. Morgan will continue his interest in radiation preservation but will have research responsibilities in other food and food processing investigative areas.

Dr. Morgan

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Bakers find Staley's Sta-Sol® Lecithin improves dispersion and emulsification of fat, and reduces stickiness of dough. Candy makers use it also to disperse fat and to give better eating and keeping qualities. In chocolate, it reduces viscosity, increases covering power and stabilizes the coating.

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Industry Publications

(Continued from 45)

A four-page bulletin, No. 2290, describing the **Aminco-Jonnard Refractometer**, a new instrument which measures refractive index differences, is now available from the American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md. The bulletin contains detailed information on the instrument's applications, operating principles, internal design and complete ordering data.

The National Dairy Council has recently published a booklet, **"Diet & Heart Disease,"** which is a summary of current information on the subject, prepared to assist professional people in making a lay interpretation of a complicated medical problem. The booklet is intended to fulfill the recommendations of the participants in the NDC 1957 Research Conference that: 1—the facts regarding diet and heart disease be reported in simplified language without bias of individual opinion; 2—current concept of what constitutes a good diet be repeated in relation to this problem; and 3—the contributions of the dairy industry be spelled out for better public understanding. Copies can be requested from the National Dairy Council, 111 N. Canal St., Chicago 6, Ill.

Nine basic types of temperatures and pressure controls are described in a new condensed catalog issued by the Powers Regulator Co., 3434 Oakton St., Skokie, Ill. Included are descriptions of self-operating regulators, water mixing elements, pneumatic control instruments, indicating and recording instruments, and control valves. Copies are available upon request to the company.

A bulletin, describing the new SWECO line of steam jet ejectors which are available in a range of sizes with single and multiple stages up to six stages, has been released by Southwestern Engineering Co., 4800 Santa Fe Ave., Los Angeles 58, Calif. Of interest to engineers is the inclusion of two Dalton's Law Charts. Chart one can be used to find the total mixture weight when weight of air and mixture pressure and temperature are known. Chart two can be used to find the mixture temperature when weight of air and air-vapor mixture are known as well as the pressure. Copies may be obtained by request.

A new 28-page catalog and price list covering the Pfanstiehl Laboratories, Inc. line of rare sugars, amino acids, laboratory reagents and biochemicals is now available from the company by writing it at 104 Lakeview Ave., Waukegan, Ill. Specifications for most products are included.

"Engineering Report on Mixing" is the title of a new four-page bulletin prepared by Rietz Manufacturing Co. for distribution to the food and chemical process industries. The bulletin is devoted entirely to continuous mixing operations, covering mixing of solids with solids, solids with liquids, heating or cooling during mixing, and the mixing of high viscosity liquids for the production of plastic or pasty masses. Free copies may be obtained by writing the company at West Chester, Penn., or Santa Rosa, Calif.

A new **sealed gear pump** for mounting on any machine which requires fluid circulation for lubrication or other purposes is pictured and described in a technical bulletin now offered by Bijur Lubricating Corp., 151 W. Passaic Ave., Rochelle Park, N. J. Two models are described, the Unidirectional, in which fluid flow reverses when shaft rotation reverses; and the reversible, in which fluid flow is always in the same direction regardless of shaft rotation. Bulletin "TR-57D" can be obtained by writing "Service" at the company.

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San-oh Kogyo Co. Ltd.
Koga-shi, Ibaraki-ken, Japan

Dr. Sylvia Y. de la Paz
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—Strong background in bacteriology. 17 yrs. exp. includes frozen and dried eggs, poultry, butter, milk, cheese, feeds, meat and poultry pot pies, frozen prepared dinners, canned meats, canned poultry, smoked meats, dried sausages, sanitation. Available for Quality Control, Product Development, Service or Sales. REPLY BOX 570, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

FOOD TECHNOLOGIST
OR CHEMIST

for product development work leading to a technical sales position. Laboratory is located in Norwalk, Connecticut. Experience with baked products desirable but not essential. Replies will be held in strict confidence. Please send complete resumé to:

R. T. VANDERBILT CO., INC.
Foods Department
230 Park Avenue, New York 17, N. Y.

DFL DAIRYLAND FOOD LABORATORIES, Inc.

ENZYMES and ENZYME Products

Lipase

Enzyme Preparations from Calf, Kid Goat and Lamb animal glandular sources.

"Mil-Lait" an enzyme modified whole milk powder for rich, distinctive flavor development in milk chocolate and other chocolate products.

Write for samples and literature

DAIRYLAND FOOD LABORATORIES, INC.
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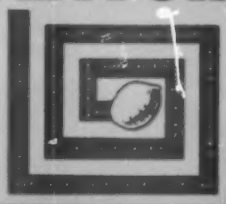
ENTRAPPED
*Reg. U.S. Pat. Office
POWDERED FLAVORS
by Florasynth



Florasynth being one of the first companies to manufacture powdered flavoring materials, we list below descriptive details of what we feel to be the finest type of New Entrapped Powdered Flavors. Features of these New Entrapped Powders are (1) as high as 50% oil content by weight. (2) Instantly dispersable. (3) Non-hygroscopic. (4) Extremely economical. Shelf life studies have indicated excellent results.

ENTRAPPED POWDERED FLAVORS

Manufactured and designed for use in Powdered Drinks, Gelatin Desserts, Cake Mixes, Pie Fillings, Puddings, Beverage Bases, Pharmaceutical Products, and wherever dry flavors can be used to good advantage.

Apple Imitation
Banana Imitation
Cherry Imitation
Cola Type
Grape Imitation
Lemon
Lemon-Lime
Lime
Loganberry Imitation
Maple Imitation
Orange
Pineapple Imitation
Raspberry Imitation
Root Beer
Strawberry Imitation
Tutti-Frutti

Other Entrapped Flavors Developed on Request.

Suggested uses per 100 lbs.:

Gelatin Dessert: Orange—Lemon—Lime—2½ to 3 oz.
Other flavors: 1¾ to 2 oz.
Cake Mixes: 2 to 4 oz.
Puddings: 2 to 3 oz.
Powdered Drinks: (without sugar) 12 oz. to 16 oz.
(1 oz. makes 2 qts. finished beverage)
Pharmaceuticals (such as aspirin) 2 to 4 oz.
Standard Packing: 150 lb. containers

ENTRAPPED POWDERED CLOUDINOL

Available for the first time to the Beverage Industry, a Dry Cloud. Does not contain any brominated oils. Two pounds when dissolved in water to one gallon will produce one gallon of Standard Cloud Solution of which one ounce per gallon of Syrup will produce an excellent suspension in the finished product. ¼ oz. will sufficiently cloud 1 gallon of finished beverage.

ENTRAPPED POWDERED CLOUDINOL
Standard Packing: 150 lb. containers

ENTRAPPED POWDERED CLOUDY FLAVORS

After years of research our Flavor Specialists have now developed Powdered Cloudy Flavors which will produce on dilution a finished beverage simulating fresh juice both in appearance and flavor. They are uniform powders which will not separate on dilution, will give a perfect Cloud and will not form a ring in the finished beverage.

Cloudy Orange
Cloudy Lemon
Cloudy Lime
Cloudy Lemon-Lime

Suggested Uses:

Syrups ..... ½ oz. per gal.
Lemonade Mix ..... 6 to 8 oz. per 100 lbs.
Lemon Bar Mix ..... 6 to 8 oz. per 100 lbs.
Powdered Drinks (without sugar) ..... 2 to 2½ lbs. per 100 lb. Mix—1 oz. makes ½ gal. Finished Beverage

Standard Packing: 150 lb. containers

Florasynth LABORATORIES, INC.

EXECUTIVE OFFICES: 900 VAN NEST AVE., (BOX 12) NEW YORK 62, N. Y. • CHICAGO 6 • LOS ANGELES 21

Cincinnati 2 • Detroit • Dallas • Memphis • New Orleans 12 • St. Louis 2 • San Francisco • San Bernardino

Florasynth Labs. (Canada Ltd.) • Montreal, Toronto, Vancouver, Winnipeg • Mexico 11, D.F.

UPON REFLECTION

You will come to Norda

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Samples, free, by sending your business letterhead to

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